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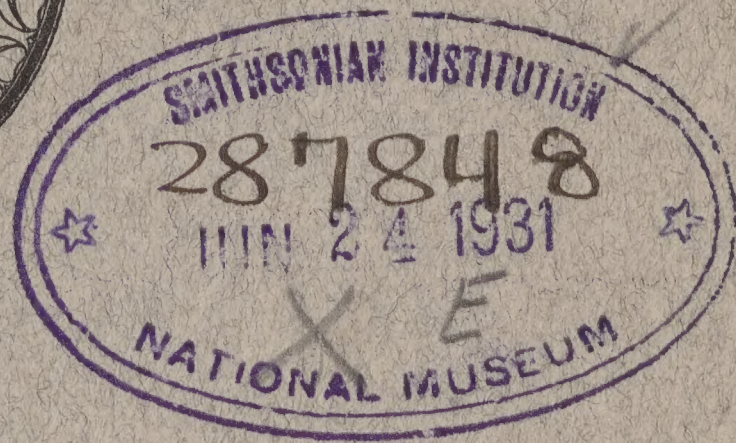
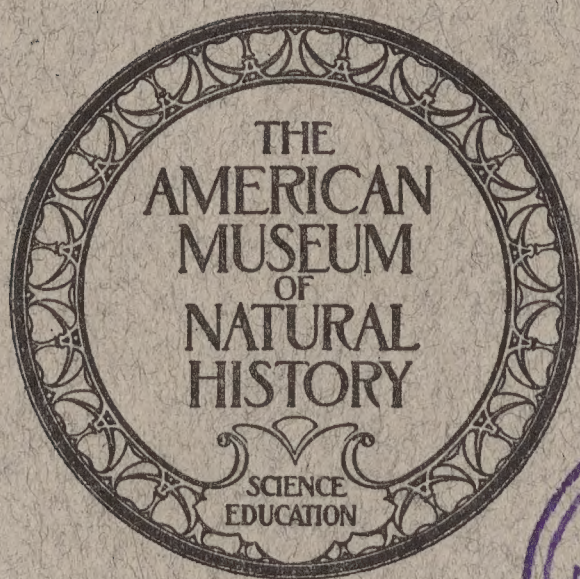
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BULLETIN
OF
THE AMERICAN MUSEUM
OF NATURAL HISTORY

VOLUME L, 1924



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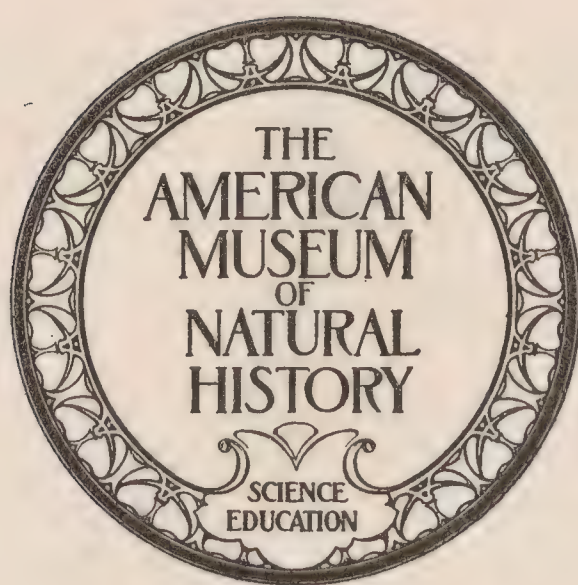
NEW YORK

PUBLISHED BY ORDER OF THE TRUSTEES

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EDITED BY
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EDMUND OTIS HOVEY

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NATURAL HISTORY MAGAZINE

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ERRATA

- Page 65, line 16 from bottom, for *Hyænarctus* read *Hyænarctos*.
- “ 70, line 7 from bottom, for *Neotragoceras* read *Neotragocerus*.
- “ 100, lines 9 and 13 from bottom, for *Ælurodon haydenianus* read *Ælurodon haydeni*.
- “ 100, line 10 from top, for *Ælurodon haydenianus validus* read *Ælurodon haydeni validus*.
- “ 104, footnote, for *Daphæus* read *Daphænus*.
- “ 104, footnote, for *Paradaphæus* read *Paradaphænus*.
- “ 106, line 15 from top, for *Amphicyon americana* read *Amphicyon americanus*.
- “ 113, line 19 from top, for *Ælurodon mæandrimus* read *Ælurodon mæandrinus*.
- “ 115, line 2 from top, for *Hyænarctes* read *Hyænarctos*.
- “ 126, line 3 from top, for *Canis morenoi* read *Canis moreni*.
- “ 206, lines 3 and 5 from bottom, for *Craniocerus* read *Cranioceras*.
- “ 305, line 6 from bottom, for two-webs read toe-webs.
- “ 305, line 19 from bottom, for *Megapodidæ* read *Megapodiidæ*.
- “ 310, line 15 from top, insert comma after paper.
- “ 311, line 1 from bottom, for grand read ground.
- “ 317, first column after *Anseres*, insert parentheses before variable and after *Nesonetta*.
- “ 328, line 18 from top, for *leucolophi* read *leucolopha*.

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Article I.—A REVISION OF PALÆOMASTODON
DIVIDING IT INTO TWO GENERA, AND WITH DESCRIPTIONS OF
TWO NEW SPECIES¹

BY H. MATSUMOTO

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I.—INTRODUCTION

The genus *Palæomastodon* was, as is well known, created by Andrews, consisting at first of only a single species, *P. beadnelli*; but subsequently he added three more species, *P. minor*, *parvus*, and *wintoni*. Then he made the fact sufficiently clear that two species, *P.*

¹This is the third of a series of contributions on the Fayûm Vertebrata by Dr. Matsumoto based upon American Museum materials. The first was prepared by Professor H. F. Osborn from extracts from Dr. Matsumoto's manuscript made by C. C. Mook. This constituted American Museum Novitates No. 51; the second contribution is entitled 'A Contribution to the Study of *Mærittherium*' and has appeared in the American Museum Bulletin, XLVIII, pp. 97-139, 1923. A fourth contribution, on the Fayûm Hyracoidea, will appear shortly in the Bulletin.—C. C. Mook.

beadnelli and *parvus*, differ very much from the other two species, *P. wintoni* and *minor*, in certain characters of the mandible and lower cheek teeth. But he did not make clear the parallel differences in the structures of the skull and upper cheek teeth, owing to the few specimens of the skull and upper cheek teeth of the genuine *beadnelli-parvus* type in his material.

As a result of my present study of the American Museum material of *Palæomastodon*, it has become clear that there are two distinct types of this genus, even in the structures of the palate (the skull as a whole is not yet known in one of the two types) and upper cheek teeth, corresponding to the two types in the structures of the mandible and lower cheek teeth, so that I have subdivided this genus into two distinct genera (or subgenera, if one be inclined to treat them so).

Schlosser was inclined to recognize only two species in this genus, corresponding to the two types just mentioned.

The difference in size between *P. beadnelli* and *parvus* and between *P. wintoni* and *minor* seems to me too great to be looked upon as sexual dimorphism, even when we admit that the genus had very high variability. I made an observation on the size variation of the cheek teeth by graphic method. Almost every molar of *P. wintoni*, material of which is the most abundant of all, shows a bimodal curve of variation. Thus we can recognize the presence of sexual dimorphism within this single species; and we have no need to consider *P. wintoni* and *minor* as the male and female types of the same species.

Andrews and Beadnell's genus *Phiomia* was afterwards proved by Schlosser and by Andrews himself to be merely a juvenile type, with deciduous dentition, of *Palæomastodon* (the paratype, however, is merely a hyracoid). Now I will try to solve the serious question as to which of the two subdivisions of *Palæomastodon* the misplaced genus *Phiomia* corresponds. According to Andrews' figures and my own observation of the type specimen of *Phiomia*, the largest and most conspicuous anterior mental foramen lies on the outer side of the symphyseal region and another smaller one lies just below the anterior lobe of Dm_3 , and this deciduous molar is typically bunodont in its structure, as well as in the mode of wearing. These features are characteristic of the *wintoni-minor* type in contrast to the *beadnelli-parvus* type. The latter type is typically *Palæomastodon*. Consequently, the former type should receive *Phiomia* as its generic name.

During my present study I have received much helpful advice from Professor Henry F. Osborn, President of the American Museum, Dr.

W. D. Matthew, Professor William K. Gregory, and Mr. Walter Granger, to all of whom my hearty thanks are due. I am likewise indebted to Dr. Charles W. Andrews of the British Museum, for advice and aid during my visit there.

II.—DESCRIPTION OF GENERA AND SPECIES

The old genus *Palæomastodon* should be subdivided into two genera as follows.

A.—Palate wide in proportion to the length of the cheek teeth series. Symphysis rather short, its posterior end lying at a considerable distance anterior to the first cheek tooth ($P_{\frac{3}{3}}$); the most conspicuous one of the anterior mental foramina lying just below the first cheek tooth, as well as a considerable distance behind the posterior end of the symphysis. Ridge-formula: $Dm_{\frac{??}{?}}^{\frac{??}{?}}$. $P_{\frac{1.2}{1.2}}^{\frac{1.1.2}{1.2}}$. $M_{\frac{2.2.2}{2.2.2-3}}^{\frac{2.2.2}{2.2.2-3}}$. Last premolars and all molars bunolophodont, appearing like typically lophodont teeth when moderately worn; no trefoil pattern of cusps.....*Palæomastodon*.

B.—Palate long and narrow. Symphysis long, its posterior end lying only a little anterior to, or posterior to the anterior end of the first cheek tooth ($P_{\frac{3}{3}}$); the most conspicuous one of the anterior mental foramina lying far anterior to the first cheek tooth, as well as to the posterior end of the symphysis. Ridge formula: $Dm_{\frac{1.2.3}{1.2.3}}^{\frac{1.2.3}{1.2.3}}$. $P_{\frac{1.2}{1.2}}^{\frac{1.1-2}{1.2}}$. $M_{\frac{3.3.2-3}{3.3.3-3}}^{\frac{3.3.2-3}{3.3.3-3}}$. Lasts premolars and all molars typically bunodont; trefoil pattern of cusps well developed.....*Phiomia*.

Palæomastodon ANDREWS

Andrews, 1901; Andrews, 1903 (pars); Andrews 1904 (pars); Andrews, 1906 (pars).

This genus should be rediagnosed as follows.

A genus of Proboscidea. Skull imperfectly known. Palate rather short and wide, as compared with that of the next genus; judging from the form of the palate this genus might be less long-skulled than the next one. Mandible elongated antero-posteriorly; mandibular symphysis rather short as compared with that of *Phiomia*; posterior end of symphysis lying a considerable distance anterior to the first cheek tooth ($P_{\frac{3}{3}}$); largest and most conspicuous one of mental foramina lying just below the first cheek tooth, and far behind the posterior end of the symphysis. Dental formula: $I_{\frac{1}{1}}^{\frac{1}{1}}$. $C_{\frac{0}{0}}^{\frac{0}{0}}$. $P_{\frac{2}{2}}^{\frac{2}{2}}$. $M_{\frac{3}{3}}^{\frac{3}{3}}$. Ridge formula: $Dm_{\frac{???}{???}}^{\frac{???}{???}}$. $P_{\frac{1.2}{1.2}}^{\frac{1.1.2}{1.2}}$. $M_{\frac{2.2.2}{2.2.2-3}}^{\frac{2.2.2}{2.2.2-3}}$. Cheek teeth markedly brachyodont; last premolars and all molars short and wide, bunolophodont, wearing like typically lophodont teeth, attaining rather sharp ridges and very widely open valleys when moderately worn; a rudimentary intermediate cusp is present in the anterior valley of each lower molar; no trefoil pattern of cusps; surface of enamel rather smooth; basal cingula neither very strong nor very rough.

GENOTYPE.—*Palæomastodon beadnelli* Andrews, 1901.

This genus, as emended here, is much less common than the next genus in the Fluvio-marine formation, as *Zygodolophodon* is less common than *Trilophodon* in the Miocene of Europe. The three species which are to be included in this genus are distinguished as follows.

1.—Length of lower molar series measuring 130 mm.; that of lower premolar and molar series, 197 mm. (Andrews' type).....*parvus*.

2.—Length of lower molar series measuring 159 mm. (type No. 14547); that of upper molar series, 150–152 mm. (paratype No. 13449); that of upper premolar and molar series, 250 mm. (ditto)...*intermedius*.

3.—Length of lower molar series measuring 194 mm.; that of lower premolar and molar series, 285 mm. (Andrews' type)...*beadnelli*.

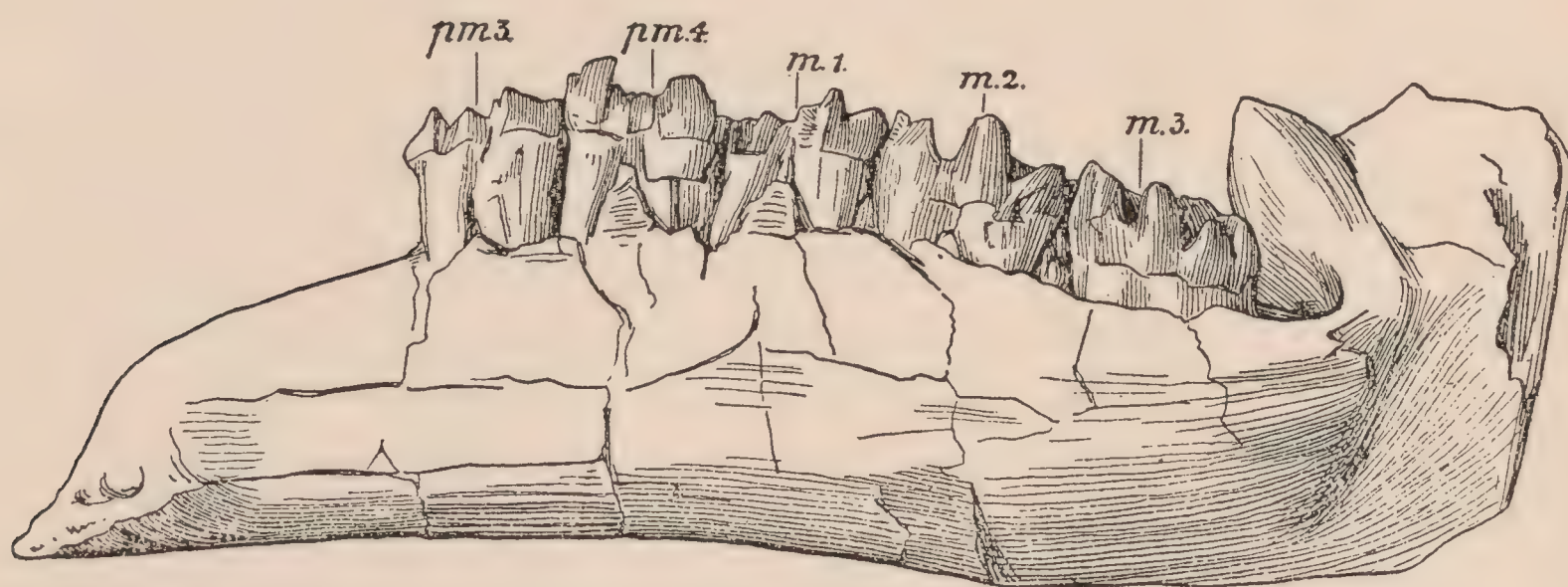


Fig. 1. Original type of *Palæomastodon parvus* Andrews, 1905.

"Right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed." Brit. Mus. No. M. 8479a. One-fourth natural size. Lateral view, left side. After Andrews, 1906. Figure inserted by Professor H. F. Osborn.

Palæomastodon parvus Andrews

P. parvus ANDREWS 1905, Geol. Mag., Decade V, II, pp. 562–563; 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 162–168, text figs. 50C, 55–59; 1908, Phil. Transact. Roy. Soc. London, Ser. B, CXCI, p. 399, text. fig. 1 (2).

SPECIMEN.—No. 13497; a left lower third molar; Amer. Mus. Exp. 1907, Quarry B, Fluvio-marine formation, Fayûm, Egypt.



Fig. 2. *Palæomastodon parvus* Andrews, 1905.

Third lower molar tooth. Amer. Mus. No. 13497. Two-thirds natural size. Crown view.

This tooth measures 52 mm. in length and 32 mm. in width. It is longer than and as wide as the lower third molar of Andrews' type, which is stated by Andrews to be 46 mm. long and about 32 mm. wide.

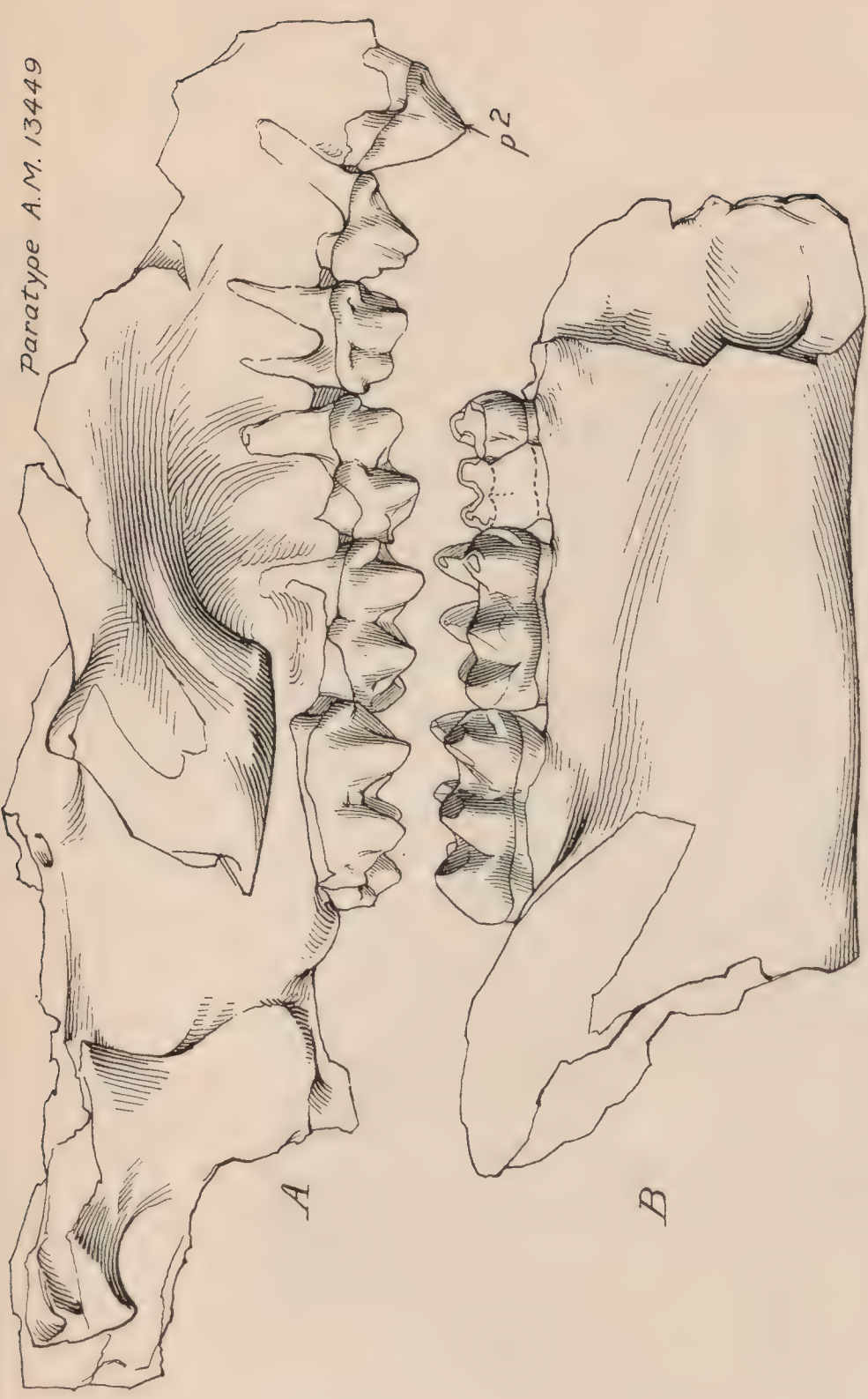
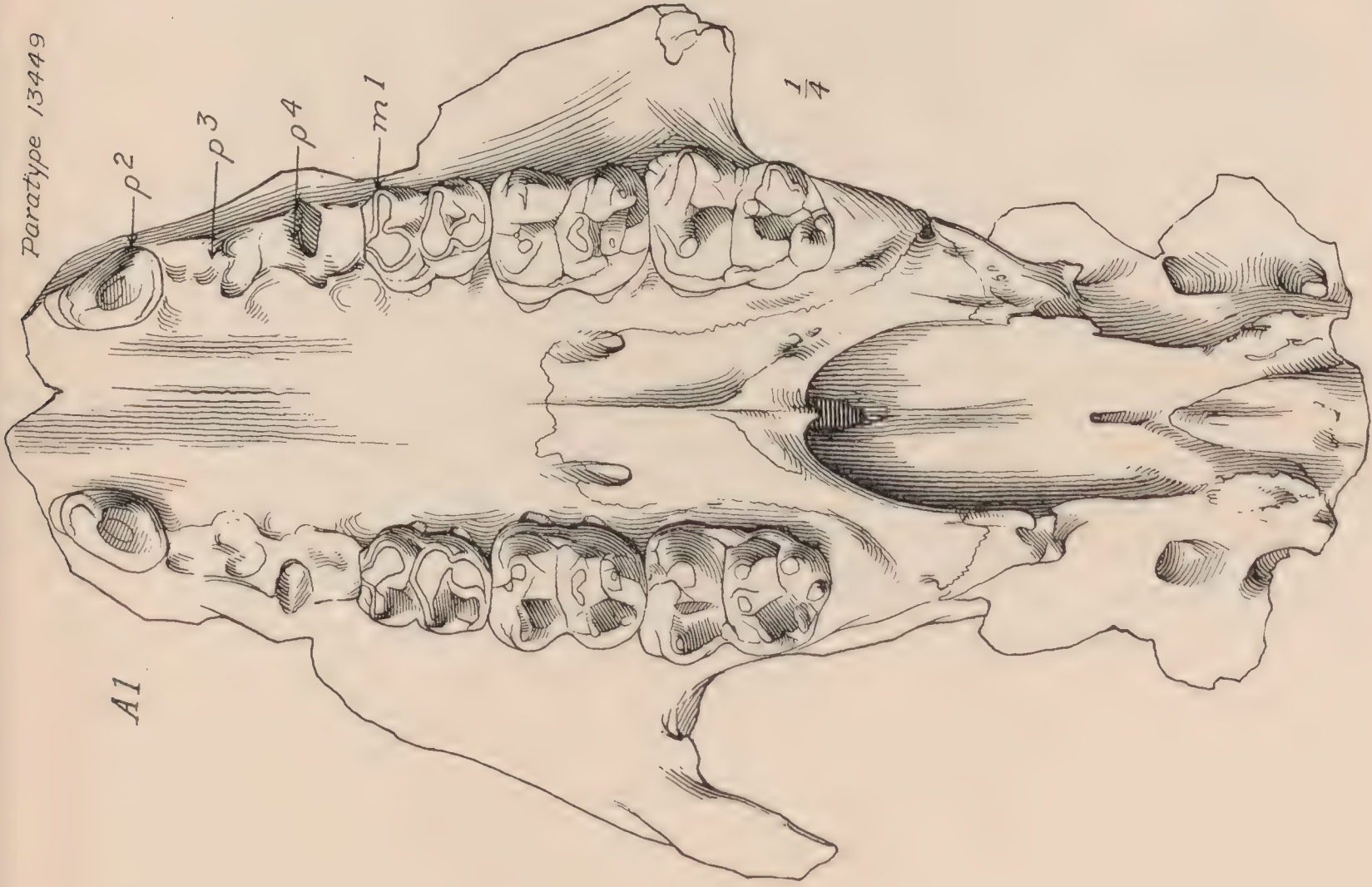


Fig. 3. *Palaeomastodon intermedius* Matsumoto, 1922.

Type and paratype specimens. A, paratype specimen. Skull, Amer. Mus. No. 13449. One-fourth natural size. Lateral view, left side. A1, the same, inferior view. B, type specimen. Part of left ramus of jaw, Amer. Mus. No. 14547. One-fourth natural size. External view (reversed in drawing). B1, the same, superior view (reversed in drawing).



Fig. 4. *Palaeomastodon intermedius* Matsumoto, 1922.
Paratype specimen. Skull. Amer. Mus. No. 13449. One-third natural size. Inferior view.



Fig. 5. *Palæomastodon intermedius* Matsumoto, 1922.
Paratype specimen. Skull. Amer. Mus. No. 13449. One-half natural size. Lateral view, left side.



Fig. 6. *Palæomastodon intermedius* Matsumoto, 1922.
Paratype specimen. Portion of maxillary with teeth. Amer. Mus. No. 14548. One-half natural size. Inferior view.



Fig. 7. *Palæomastodon intermedius* Matsumoto, 1922.
Paratype specimen. Portion of maxillary with teeth. Amer. Mus No. 14548.
One-half natural size. Lateral view, left side.



Fig. 8. *Palæomastodon intermedius* Matsumoto, 1922.
Part of maxillary with teeth Amer. Mus. No. 13457. One-half natural size.
Inferior view.

Table A

	<i>P. parvus</i>		<i>P. intermedius</i>				<i>P. beadnelli</i>	
	Lower		Upper		Lower		Upper	Lower
	13497	Andrews	13449		14548	13480	Andrews	13481
$P_{\bar{2}}$ { Length Width			right	left	....	....	....	....
$P_{\bar{3}}$ { Length Width								
$P_{\bar{4}}$ { Length Width		35±	....	....	32	....	....	41±
$M_{\bar{1}}$ { Length Width					26.5	....	....	....
$M_{\bar{2}}$ { Length Width		35±	....	....	33	....	....	48
$M_{\bar{3}}$ { Length Width					31.5	....	....	33±
Length of P-M		38	44	44	44.5	....	....	48
Length of M-M		30±	34	34	34	....	....	37±
		45	51	51	51	....	56	65
		32	42	41	43	....	48	51
	52	46	57.5	59	....	59	65	78
	32	32±	45.5	46	....	38	52	53
		197	250	250	....	....	....	285
		130	150	152	....	....	....	194

***Palæomastodon intermedius*, Matsumoto¹**

TYPE.—No. 14547; a fragment of left mandibular ramus, bearing all three molars *in situ*, and with parts of alveoli of penultimate and last premolars; Amer. Mus., 1909.

PARATYPES.—No. 13480; a fragment of left mandibular ramus, bearing last molar and posterior root of penultimate molar *in situ*; Amer. Mus. Exp. 1907, Quarry B. No. 13449; a large fragment of skull, consisting chiefly of the palate, bearing anterior premolars (P^2) and all molars of both sides *in situ*, and with alveoli of penultimate and last premolars of both sides; Amer. Mus. Exp. 1907. No. 14548; a fragment of skull and palate, bearing penultimate premolar to penultimate molar of left side *in situ*; purchase, 1909.

All the specimens, Fluvio-marine formation of the Fayûm, Egypt.



Fig. 9. *Palæomastodon intermedius* Matsumoto, 1922.

Part of skull. Amer. Mus. No. 13458. Two-thirds natural size. Inferior view.

The ramus of the type-specimen, No. 14547, measures as follows (in mm.).

Height of Ramus on Outer Side at First Ridge of M_I	94
Ditto at First Ridge of $M_{\frac{3}{2}}$	94
Width of Ramus at First Ridge of M_I	50
Ditto at Second Ridge of $M_{\frac{2}{2}}$	51

In all the lower molars the third ridge is rather poorly developed, being distinctly narrower than the first and second ridges; the posterior valley is distinctly narrower antero-posteriorly and shallower than the anterior valley; so that the third ridge looks simply like a talon. As a

¹Amer. Mus. Novitates, No. 51, p. 2, 1922.

generic character, the very bottoms as well as the walls of the valleys were worn, even in the very earlier stages of wearing.

The palate of specimen No. 13449 measures as follows (in mm.).

Length from the Frontal Plane Tangential to the Anterior Limits of the Crowns of the two P ² to the tip of the Posteriorly Directed Process at the Posterior Limit of the Median Suture between the Two Palatines.....	250.
Distance between the Two P ²	53.
Ditto between the Two M ¹	77.
Ditto between the Two M ³	75.

All the upper molars are distinctly bilophodont, as a generic character, the rudiment of the third ridge being much feebler and much less conspicuous than that of the lower molars. The mode of wearing corresponds well to what is stated of the lower molars. Besides, all the generic characters of all the cheek teeth of this species are the same as those stated in the diagnosis of the genus.

The dimensions of the cheek teeth of this and other species of this genus at hand, in comparison with those stated by Andrews, are indicated, in millimeters, in Table A, p. 9.

Palæomastodon beadnelli Andrews

P. beadnelli ANDREWS, 1901, 'Tagebl. d. V. International Zool. Congr., Berlin,' No. 6, p. 4¹; 1901, Geol. Mag., Decade IV, VIII, pp. 401-403, text-fig. 1; 1902, 'Verhandl. d. V. International Zool. Congr., Berlin,' p. 528¹; 1903, Phil. Transact. Roy. Soc. London, Ser. B, CXCVI, pp. 110-113 (*pars*)²; 1904, Geol. Mag., Decade V, I, pp. 112-115 (*pars*)²; 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 150-166 (*pars*),³ text-figs. 50A, 51-52, Pl. xv, figs. 1-3, Pl. xvi, figs. 1-4; 1908, Phil. Transact. Roy. Soc. London, Ser. B, CXCI, p. 399, text-fig. 1 (4). SCHLOSSER, 1911, Beitr. z. Pal. u. Geol. Österreich-Ungarns u. d. Orients, XXIV, pp. 135-139 (*pars*).

P. wintoni ANDREWS, 1906, *loc. cit.*, pp. 152-162 (*pars*).⁴

SPECIMEN.—No. 13481; a right lower third molar attached to a small fragment of mandibular ramus; Amer. Mus. Exp. 1907, Quarry B, Fluvio-marine formation, Fayûm, Egypt.

This tooth measures 81 mm. in length and 45 mm. in width. It is narrower than the lower third molars described by Andrews under this species, and slightly narrower than a specimen provisionally described by him under *P. wintoni*, but which I, as well as he himself lately, look upon as belonging to *P. beadnelli*.

¹These reports were not actually seen by me.

²The greater portions of Andrews' descriptions and all the text-figures in these reports correspond, in my opinion as well as in later opinion of Andrews, not to this species but to *Phiomia wintoni*.

³All the principal specimens of skulls and upper jaws except that illustrated in his Pl. xv, fig. 2, in this report belong, in my opinion, as well as in later opinion of Andrews, not to this species but to *Phiomia wintoni*.

⁴Andrews' specimen numbered M. 8849b was lately labelled correctly by Andrews as *P. beadnelli*,



Fig. 10. *Palæomastodon beadnelli*, Andrews, 1901.

Original type figure. Type specimen "nearly complete left ramus of the mandible of a Proboscidean . . ." Geol. Mus. Cairo No. C10014. One-sixth natural size. A, superior view. B, external view. After Andrews, 1901. Figure inserted by Professor H. F. Osborn.



Fig. 11. *Palæomastodon beadnelli* Andrews, 1901.

Right third lower molar, with fragment of jaw. Amer. Mus. No. 13481. Two-thirds natural size. Superior view.

Among so many specimens of crania and upper jaws, which were provisionally referred to this species by Andrews, one shown in his Pl. xv, fig. 2, representing a fragment of palate with the second and third molars *in situ*, appears to me really to belong to this species. These teeth are clearly shown to be bilophodont, a generic character.



Fig. 12. *Phiomia serridens* Andrews and Beadnell, 1902.

Original type figure. Type specimen. Anterior portion of a left mandibular ramus, bearing DI_2 and DM_{2-3} *in situ*. Geol. Mus. Cairo No. C10007. One-half natural size. Upper figure, superior view. Lower figure, external view. After Andrews and Beadnell, 1902. Figure inserted by Professor H. F. Osborn.

PHIOMIA Andrews and Beadnell

Andrews and Beadnell, 1902 (*pars*); Andrews, 1906.

This genus should be rediagnosed as follows.

A genus of Proboscidea. Skull long in proportion to its width, although less so than that of typical *Trilophodon* and *Megabelodon*; sagittal crest present; external nares located just anterior to orbits; palate long. Mandible elongated; mandibular symphysis very long, although less so than that of typical *Trilophodon* and *Megabelodon*; posterior end of symphysis lying but a little anterior or posterior to the

anterior limit of cheek tooth series; largest and most conspicuous one of the anterior mental foramina lying a considerable distance anterior to the first cheek tooth ($P_{\frac{1}{3}}$), as well as to the posterior end of symphysis. Dental formula: $I_{\frac{1}{1}}^{\frac{1}{1}}. C_{\frac{0}{0}}^{\frac{0}{0}}. P_{\frac{2}{2}}^{\frac{2}{2}} M_{\frac{3}{3}}^{\frac{3}{3}}$. Ridge formula: $Dm_{\frac{1.2.3}{1.2.3}}^{\frac{1.2.3}{1.2.3}}. P1. \frac{1.1-1.2}{1.2}. M3. \frac{3.3.2-3}{3.3.3-3}$. Cheek teeth markedly brachyodont; last premolars and all molars rather long and narrow, typically bunodont; an intermediate cusp is present in the anterior valley of each lower molar; trefoil pattern of cusps well developed; surface of enamel very rough; basal cingula strong and very rough.

GENOTYPE.—*Phiomia serridens* Andrews, 1902, which appears to be identical probably with *Palæomastodon wintoni* Andrews, 1905, or possibly with *Palæomastodon minor* Andrews, 1904.

This genus, as emended here, is very common in the Fluvio-marine formation.



Fig. 13. *Palæomastodon barroisi* Pontier, 1907.

Original type figures. Type specimens. Last left superior and inferior molars. Three-fifths natural size. After Pontier, 1907. Figure inserted by Prof. H. F. Osborn.

The three species which are to be included in this genus are distinguished as follows.

1.—Posterior end of mandibular symphysis situated a little anterior to $P_{\frac{1}{3}}$; in $M_{\frac{1.2}{1.2}}$, the third ridge is distinctly feebler than the first and second; $M_{\frac{3}{3}}$ not exceedingly long and narrow, three-ridged, the posterior talon being not exceedingly prominent; length of lower molar series measuring 126 (Andrews' type)—147 (No. 13471) mm.; that of lower premolar and molar series, 180 (Andrews' type)—202 (No. 13471) mm.; that of upper molar series, 125–130 mm. (Nos. 13455; 13448); that of upper premolar and molar series, 205–215 mm. (ditto)...*minor*

2.—Mandibular symphysis and lower molars similar to those of the preceding species except in size; length of lower molar series measuring 160 (No. 13474)—173 (Andrews) mm.; that of lower premolar and molar series, 225–250 mm. (Nos. 13474; 13477); that of upper molar series, 145–170 mm. (Andrews); that of upper premolar and molar series, 255–284 mm. (ditto).....*wintoni*.

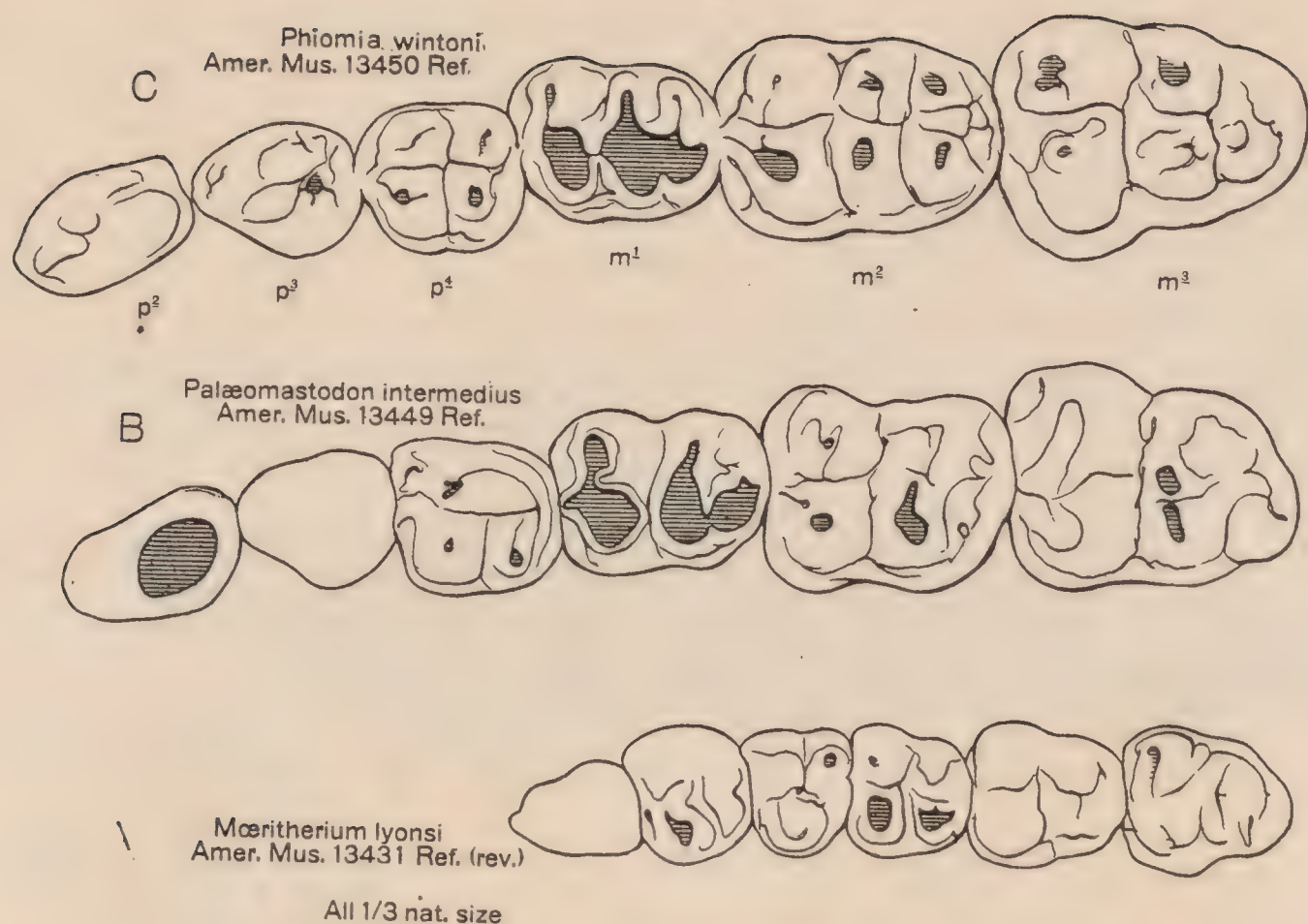


Fig. 14. *Mærittherium lyonsi* Andrews, Amer. Mus. No. 13431 (A); *Palæomastodon intermedius* Matsumoto, Amer. Mus. No. 13449 (B); and *Phiomia wintoni* (Andrews), Amer. Mus. No. 13450 (C).

Superior grinding teeth. One-third natural size. Crown views.

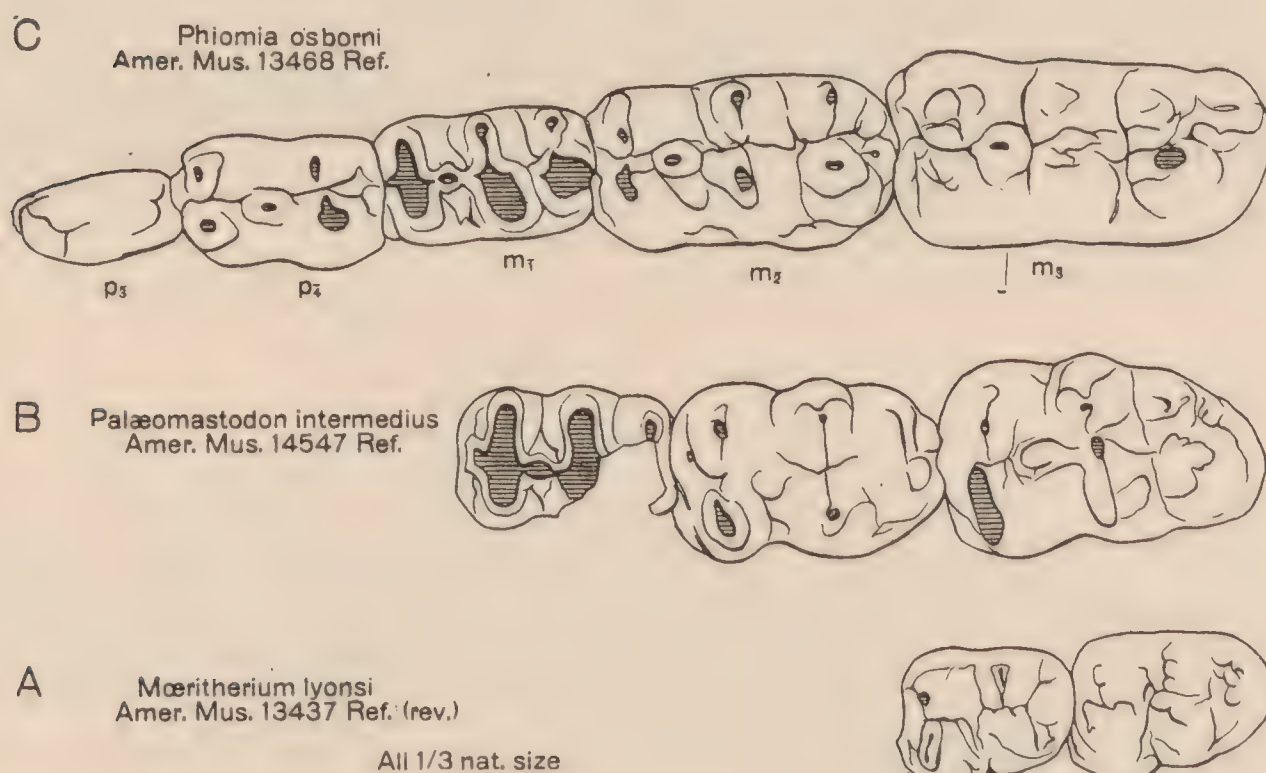


Fig. 15. *Mærittherium lyonsi* Andrews, Amer. Mus. No. 13437 (A); *Palæomastodon intermedius* Matsumoto, Amer. Mus. No. 14547 (B); and *Phiomia osborni* Matsumoto, Amer. Mus. No. 13468 (C).

Inferior grinding teeth. One-third natural size. Crown views.

3.—Posterior end of mandibular symphysis situated a little posterior to the anterior end of $P_{\bar{3}}$; in $M_{\bar{1},2}$, the third ridge is almost as well developed as the first and second, the widest part of the tooth corresponding to the third ridge; $M_{\bar{3}}$ exceedingly long and narrow, nearly four-ridged, the fourth ridge corresponding to the prominently developed posterior talon; length of lower molar series measuring 177–180 mm.; that of lower premolar and molar series, 250–255 mm. (type: No. 13468).

osborni.

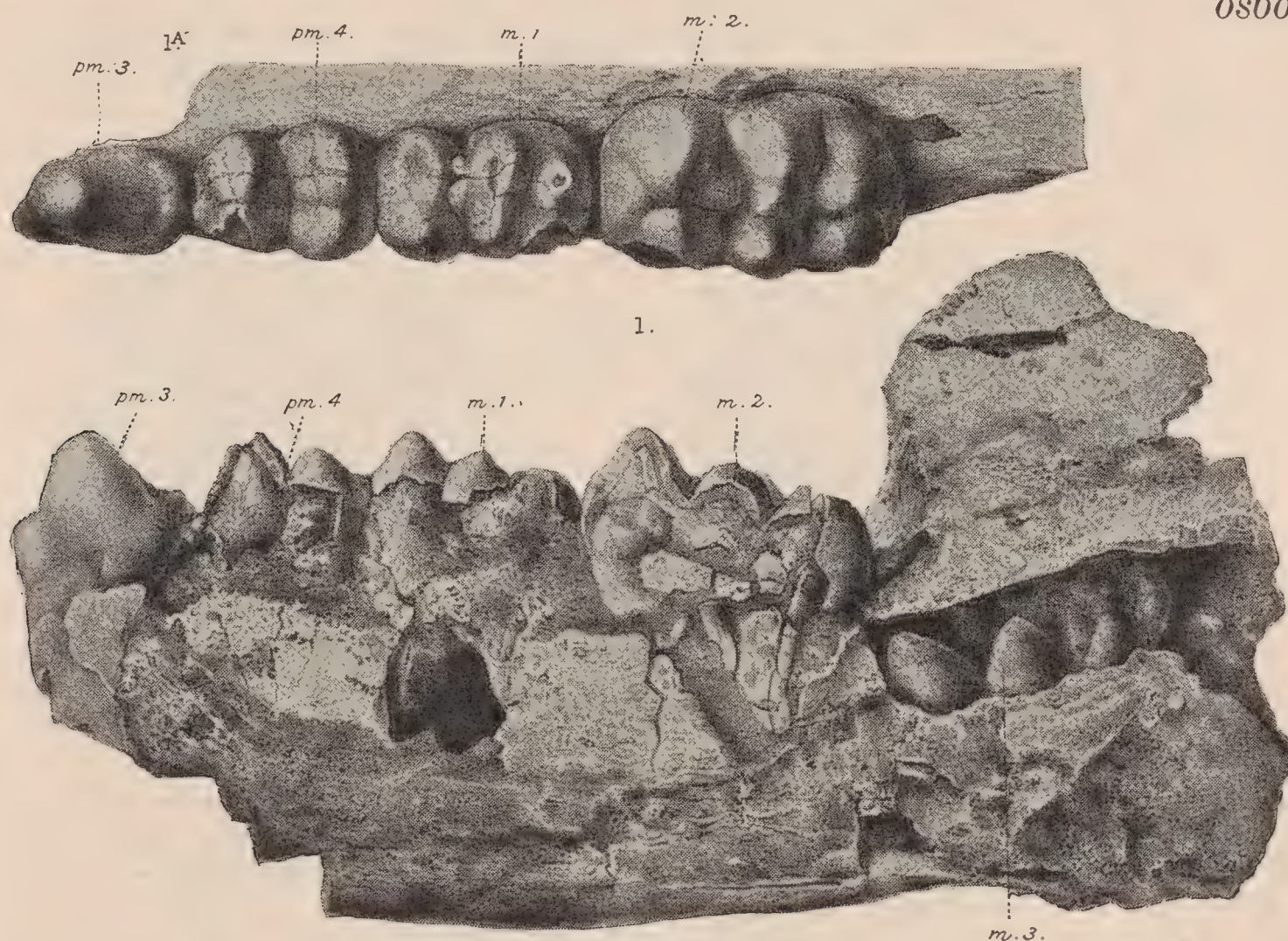


Fig. 16. *Palæomastodon minor* Andrews, 1904 = *Phiomia minor* (Andrews).

Original type figures. Type specimen. "Part of the ramus [right] and the coronoid process of an immature mandible, in which m.3 has not yet been cut, although it is completely developed." Brit. Mus. No. M. 8479b. One-half natural size. Upper figure, internal view. Lower figure, superior view. After Andrews, 1906. Figure inserted by Prof. H. F. Osborn.

Phiomia minor (Andrews)

Palæomastodon minor ANDREWS, 1904, Geol. Mag., Decade V, I, p. 115; 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 168–169, text-fig. 50D, Pl. XIV, fig. 1.

*Palæomastodon minus*¹ ANDREWS, 1905, Geol. Mag., Decade V, II, p. 562.

Palæomastodon beadnelli ANDREWS, 1906, *loc. cit.*, pp. 150–156 (*pars*).²

Palæomastodon wintoni ANDREWS, 1906, *loc. cit.*, pp. 156–162 (*pars*).³

Palæomastodon barroisi PONTIER, 1907, Ann. Soc. Geol. Nord., XXXVI, pp. 150–154 (*pars*),⁴ text-fig. 2 (*non* text-fig. 1).

¹Evidently a misprint for "*minor*."

²Andrews' specimen numbered C. 9296, appears to me to belong to this species.

³Andrews' specimen numbered C. 8457, possibly as well as that numbered M. 8849a, appears to me to belong to this species.

⁴The last lower molar of Pontier's two cotypes falls within the limit of variation of *P. minor*; it may belong to the supposed male types of the same species.

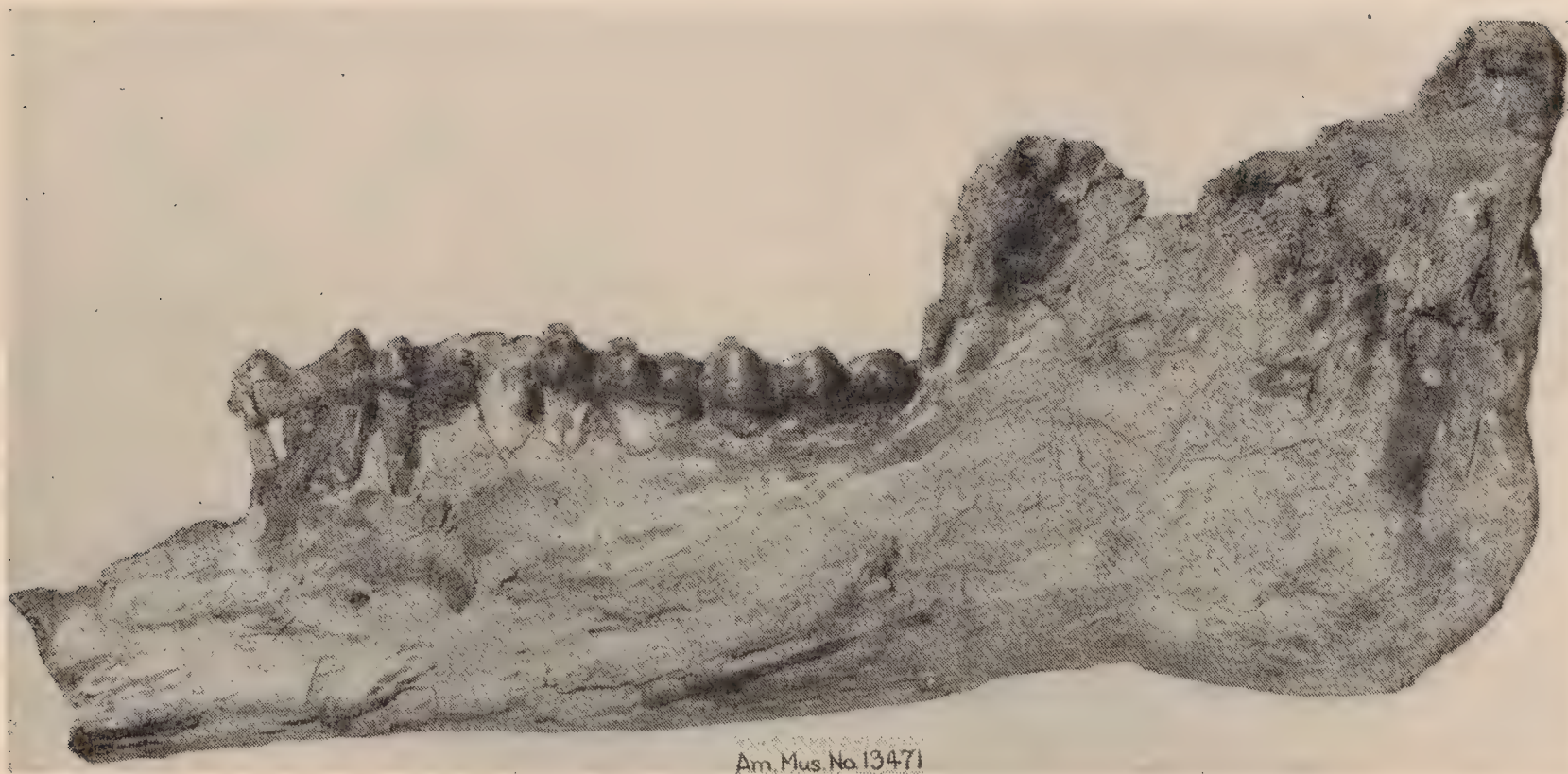


Fig. 17. *Phiomia minor* (Andrews).

Left ramus of mandible. Amer. Mus. No. 13471. One-fourth natural size. External view.

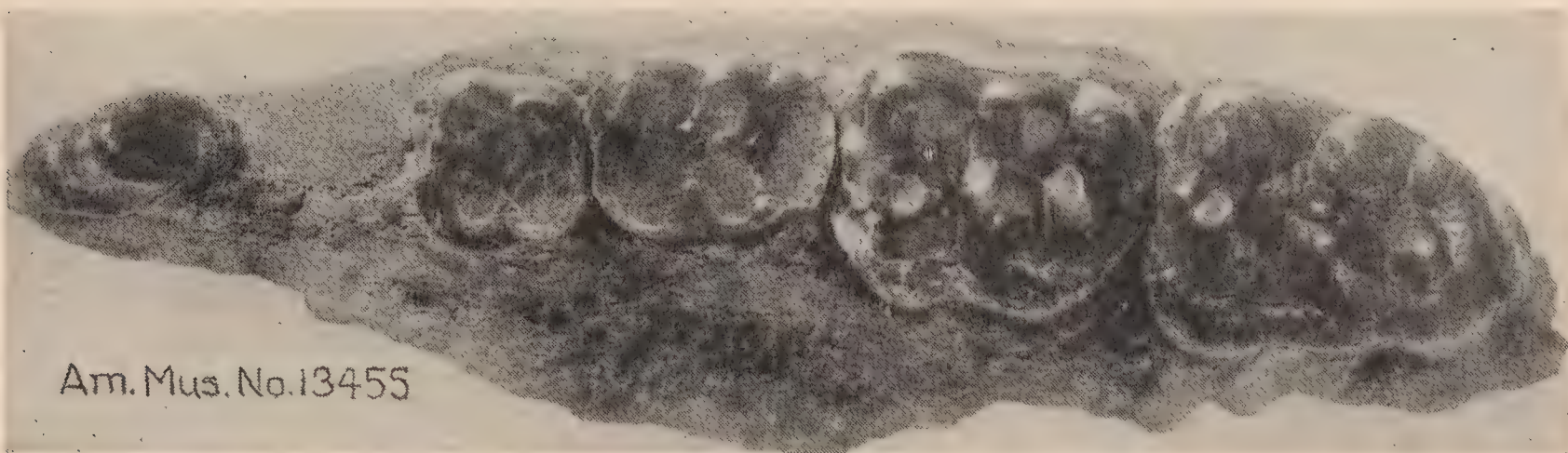


Fig. 18. *Phiomia minor* (Andrews).

Part of palate, with dentition. Amer. Mus. No. 13455. One-half natural size. Upper figure, external view. Lower figure, palatal view.

SPECIMENS.—No. 13469; a nearly complete mandible bearing supposed canine and last premolar and first and second molars of right side, and both premolars and first and second molars of left side *in situ*, and with alveoli of lower tusks of both sides, of anterior premolar ($P_{\frac{3}{2}}$) of right side and of supposed canine of left side, the last molars of both sides having not yet erupted; Amer. Mus. Exp. 1907, 8 miles west of Quarry A.

No. 13471; a mandible bearing all the teeth *in situ*; Amer. Mus. Exp. 1907, Quarry B.



Fig. 19. *Phiomia minor* (Andrews).

Part of right mandibular ramus, with second and third lower molars. Amer. Mus. No. 13483. One-half natural size. Superior view.



Fig. 20. *Phiomia minor* (Andrews).

Part of right mandibular ramus. Amer. Mus. No. 13475. One-third natural size. Superior view.

No. 13475; a fragment of right mandibular ramus with last premolar and first and second molars *in situ*, besides roots of anterior premolar, and a much crushed last molar in the alveolus; Amer. Mus. Exp. 1907, Quarry B.

No. 13483; a fragment of right mandibular ramus bearing second and third molars *in situ*; Amer. Mus. Exp. 1907, Quarry B.

No. 13486; a fragment of right mandibular ramus with roots of premolars *in situ*; Amer. Mus. Exp. 1907, near Quarries.

Extra No.; two isolated right lower third molars; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated right lower third molar, its crown being broken and imperfectly represented. Amer. Mus. Exp. 1907, near Quarries.

Extra No.; an isolated left lower anterior premolar; Amer. Mus. Exp. 1907.

No. 13448; a skull bearing all upper cheek teeth *in situ*; Amer. Mus. Exp. 1907.

No. 13455; a fragment of upper jaw with anterior and last premolars, and all molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry B.

Extra Nos.; three isolated, left upper third molars; Amer. Mus. Exp. 1907, Quarry A.

Extra No., an isolated right upper third molar; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; a fragment of upper jaw bearing anterior and next premolars of right side *in situ*; Amer. Mus. Exp. 1907, west of Quarries.

Extra No.; an isolated left upper penultimate premolar; Amer. Mus. Exp. 1907, Quarry B.



Fig. 21. *Phiomia minor* (Andrews).

Right upper tusk. Amer Mus. No. 13461. One-half natural size.

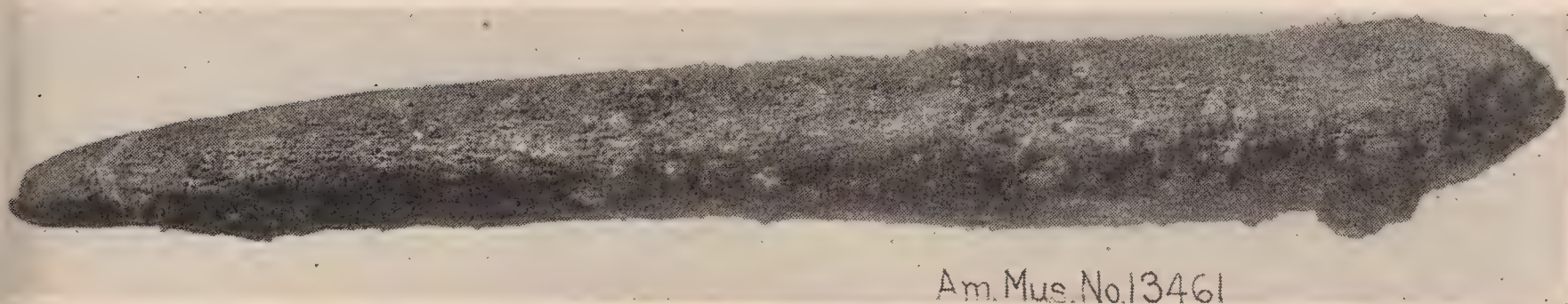


Fig. 22. *Phiomia minor* (Andrews).

Right upper tusk. Amer. Mus. No. 13467. One-half natural size.

The following upper tusks are provisionally referred to this species, according to their small size:

No. 13461; an isolated right upper tusk; Amer. Mus. Exp. 1907, Quarry B.

No. 13464; an isolated right upper tusk; Amer. Mus. Exp. 1907, 8 miles west of Quarry A.

No. 13465; a fragment of right upper tusk; Amer. Mus. Exp. 1907, Quarry A.

No. 13467; an isolated right upper tusk; Amer. Mus. Exp. 1907.

All the specimens: Fluvio-marine formation of the Fayûm, Egypt.

The mandible of specimen No. 13469 is very aberrant in having an extra pair of front teeth just behind the alveoli of the normal tusks. These extra teeth cannot be looked upon as deciduous teeth because (1) this specimen, though young (the last molars not having yet erupted), is too old to bear deciduous front teeth; (2) the position of the extra teeth is quite different from that of either deciduous or permanent lower tusks; and (3) the shape and structure of the same are quite different from those of the deciduous lower tusks of this genus. The extra teeth might be either the last incisors or the canines, possibly the latter, re-

appeared through atavism. The right tooth preserved in this specimen *in situ* is short, stout, conical, with the tip pointed forward and upward; upper side slightly concave and lower side markedly convex in lateral view; it appears to be rootless; it measures 32 mm. in antero-posterior extension, about 21 mm. in estimated vertical width, and about 13 mm. in lateral width; its distal part is covered with enamel on all sides, the enamel extending farther backward on the outer surface than on the inner. The maximum diameter of the alveoli of the lower tusks is about 27 mm., and the shorter diameter of the same about 14 mm.

The mandibles of the specimens Nos. 13469, 13471 and 13475, in comparison with one described by Andrews, measure as follows (in mm.).

	13469 Young; prob. ♀	13471 prob. ♂	13475 Young; prob. ♀	Andrews prob. ♂
Length from Tip of Symphysis to Posterior Side of Angle	435±	590±	....	600
Length of Symphysis	137	215	....	226
Length from Tip of Symphysis to Posterior Side of M ₃	....	435	....	475
Minimum Antero-posterior Width of Ascending Bar	122	155	....	....
Maximum Width of Anterior Half of Symphysial Region	65	....	....	....
Minimum Width at the Constriction of Symphysial Region	60	....	....	55
Height of Ramus at P ₃	61	83	70	....
Ditto at M ₁	59	90	72	....
Ditto at Anterior Lobe of M ₃	....	82	....	....
Height of Ascending Bar at Condyle	112±	190	....	....

The mandible of specimen No. 13471 is rather large in its dimensions among the mandibles of the present species. It has rather large last molars; but closer examination leads one to witness the fact that the dimensions of all the other cheek teeth, as well as the length of symphysis, approach those of the present species, so that I have come to look upon this specimen, as well as others similar to this, as representing the male type of the present species. Andrews appears to have selected terminal individuals as the types of his species. For instance, his type of the present species does not stand at or near the average point of the smaller forms of this genus. Moreover, the last molars of his type were un-

doubtedly embryonic, having not yet erupted from their alveoli. Such an embryonic molar must be smaller than the size which should be attained by the tooth in full-grown condition. Each lower tusk of the present specimen measures 42 mm. in maximum diameter, and about 36 mm. in lateral extension *in situ*.

The dimensions of the lower cheek teeth at hand, as well as those reported by Andrews and by Pontier, are indicated, in millimeters, in Table B, p. 22.

The skull of specimen No. 13448, Prob. ♂, measures as follows (in mm.).

Basal Length (including a restored part to a short extent).....	460±
Length from Anterior Ends of Nasals to Tips of Lambdoid Crest.....	290
Length of Palate along Median Line.....	290±
Width of External Nares.....	73
Minimum Interorbital Width.....	150
Distance between the Two P ²	58
Ditto between the Two P ³	56
Ditto between the Two M ¹	44
Ditto between the Two M ³	51
Lateral Extension of the Two Occipital Condyles.....	120
Width of Foramen Magnum.....	46
Height of Occiput, including Condyles.....	162
Height of Foramen Magnum.....	35

The upper tusks of specimens Nos. 13461 and 13467 measure as follows (in mm.).

	13461	13467
	Prob. ♂	Prob. ♀
Straight Length.....	241	197
Length Along Upper Anterior Curve.....	275	226
Maximum Longer Diameter.....	40	38
Maximum Shorter Diameter.....	26	20

The fragmentary upper tusk of the specimen No. 13464 is much less curved and much less compressed laterally than the two specimens just mentioned. It is about 24 mm. thick at the portion where it measures 33 mm. in longer diameter. There may be some possibility that it actually belongs to a genus other than that to which the two above-mentioned tusks belong.

The dimensions of the upper cheek teeth, in comparison with those stated by Andrews, are indicated, in millimeters, in Table C, p. 23.

Table B

	13469		13471		13475	13483	13486	ex.	ex.	ex.	ex.	ex.	ex.	Andrews			Pontier
	Young; prob. ♀ right left		Prob. ♂ right left		Young	Prob. ♀	Prob. ♂	Prob. ♀	Prob. ♂	Prob. ♂	Prob. ♂	ex.	Young prob. ♀	Prob. ♂	Prob. ♀	Prob. ♂	
$P_{\overline{3}}$	....	....	25.5	29	....	....	27 ±	....	....	....	....	31	28	29	....	....	
	....	....	16	16	....	....	(roots)	....	....	....	....	15.5	16	14	....	....	
$P_{\overline{4}}$	25.5	26	31	31	30.5	....	30 ±	....	....	....	....	....	26	35	....	....	
	18	20	23	23	21	....	....	....	....	....	....	....	20 ±	20	....	....	
$M_{\overline{1}}$	34	34	35	33.5	39	....	....	....	....	....	....	..	32	38	....	....	
	25	22	26	25 ±	24	....	....	....	....	....	....	....	21 ±	25	....	....	
$M_{\overline{2}}$	48	46	47.5	49	48.5	47	....	....	....	....	....	....	45	54	....	....	
	31	30	30.5	31	28	30	....	....	....	....	....	....	29 ±	31	....	....	
$M_{\overline{3}}$	....	....	63.5	65	....	55	....	57	63 ±	63 ±	63 ±	....	48	66	56	62	
	....	....	....	37	....	33	....	32	35	33 ±	33 ±	....	29	35	....	35	
Length of P-M		....	198	202	....	....	....	....	....	....	....	....	180	....	....	....	
Length of M-M		....	145	147	....	....	....	....	....	....	....	....	126	....	....	....	

Phiomia wintoni (Andrews)

? *Phiomia serridens* ANDREWS AND BEADNELL, 1902, 'Prelim. Note on N. Mamm. from Up. Eoc. of Egypt,' Geol. Mus., Cairo, pp. 3-5 (*pars*),¹ figs. 1, 2 (*non* fig. 3). ANDREWS, 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 170-171, Pl. xviii, fig. 4.

Palæomastodon beadnelli ANDREWS, 1903, Phil. Transact. Roy. Soc. London, Ser. B, CXCI, pp. 110-113 (*pars*), text-fig. 10-13; 1904, Geol. Mag., Decade V, I, pp. 112-115 (*pars*), text-fig. 2; 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 150-156 (*pars*), Pl. xii, fig. 1, Pl. xiii, fig. 1, Pl. xiv, fig. 2.

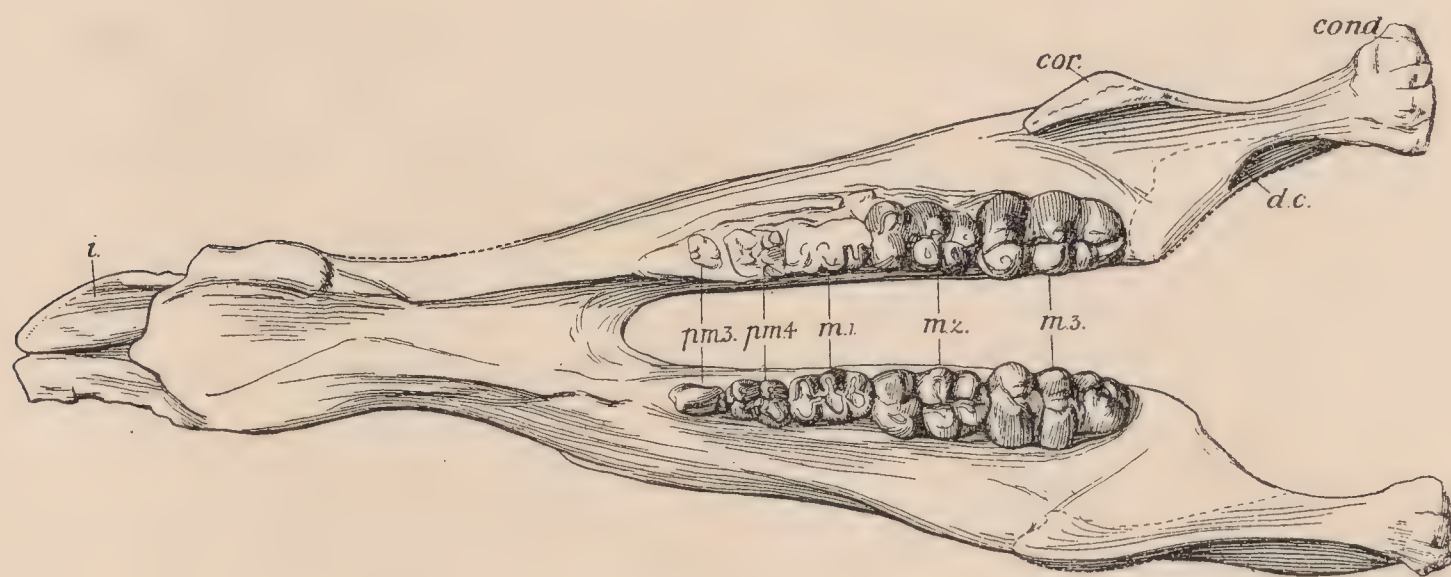


Fig. 23. *Palæomastodon wintoni* Andrews, 1905 = *Phiomia wintoni* (Andrews).

Original type figure. Type specimen, "a mandible with the incisors and posterior molars *in situ*." Brit. Mus. No. M. 8414. One-eighth natural size. Superior view. After Andrews, 1906. Figure inserted by Prof. H. F. Osborn.

Palæomastodon wintoni ANDREWS, 1905, Geol. Mag., Decade V, II, p. 563; 1906, 'Brit. Mus. Cat. Tert. Vert. Fayûm, Egypt,' pp. 156-162 (*pars*), text-figs., 50B, 53, 54, Pl. xiv, fig. 3; 1907, Geol. Mag., Decade V, IV, p. 97; 1908, Phil. Transact. Roy. Soc. London, Ser. B, CXCI, pp. 393-407, text-figs. 1 (3), 2, Pl. xxxi, figs. 1-4; Pl. xxxii, figs. 1-4. SCHLOSSER, 1911, Beitr. z. Pal. u. Geol. Österreich-Ungarns u. d. Orients, XXIV, pp. 135-139 (*pars*).

Palæomastodon barroisi PONTIER, 1907, Ann. Soc. Geol. Nord, XXXVI, pp. 150-154 (*pars*),² text-fig. 2 (*non* text-fig. 1).

SPECIMENS.—No. 13470; a mandible, bearing all premolars and first and second molars of both sides *in situ*, last molars having not yet erupted; Amer. Mus. Exp. 1907.

No. 13474; a fragment of right mandibular ramus, bearing second and third molars *in situ*, and with roots of all premolars and first molar; Amer. Mus. Exp. 1907, Quarry B.

No. 13476; a right mandibular ramus, bearing last premolar and all molars *in situ*, and with roots of anterior premolar; Amer. Mus. Exp. 1907, Quarry B.

¹The paratype (Andrews' fig. 3) of *Phiomia serridens* is merely a hyracoid, as subsequently referred to by Andrews himself.

²The last upper molar of Pontier's two cotypes appears to me to belong to the presumed female type of the species.



Fig. 24. *Phiomia wintoni* (Andrews).

Right ramus of mandible. Amer. Mus. No. 13476. One-third natural size. Upper figure, superior view. Lower figure, external view.

No. 13477; a horizontal bar, including part of symphysis, of left mandibular ramus, bearing first and second molars *in situ*, with alveoli of all premolars and first molar; Amer. Mus. Exp. 1907, Quarry B.

No. 13484; a fragment of left mandibular ramus, bearing last premolar and first molar *in situ*, and with roots of anterior premolar; Amer. Mus. Exp. 1907, Quarry B.

No. 13485; a fragment of right mandibular ramus, bearing last molar *in situ*; Amer. Mus. Exp. 1907, Quarry C.

No. 13494; fragment of left mandibular ramus, with part of symphysis, and bearing last premolar and first and second molars *in situ*; Amer. Mus. Exp. 1907, near Quarry B.

Extra No.; a fragment of left lower third molar, attached to a small fragment of mandible; Amer. Mus. Exp. 1907, Quarry B.



Fig. 25. *Phiomia wintoni* (Andrews).

Portion of left ramus of mandible. Amer. Mus. No. 13494. One-half natural size. External view.

Extra No.; an isolated right lower second molar; Amer. Mus. Exp. 1907, Quarry A.

Extra Nos.; two isolated left lower second molars; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; a fragment of right lower second molar; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated left lower first molar; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; a crown of embryonic right lower first molar; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated left lower last premolar; Amer. Mus. Exp. 1907, Quarry A.

Extra No.; an isolated left lower last premolar; Amer. Mus. Exp. 1907, Quarry B.

No. 13450; a fragment of skull and palate, bearing all premolars and molars of both sides *in situ*; Amer. Mus. Exp. 1907.

No. 13451; a fragment of skull and palate bearing all molars of both sides *in*



Am. Mus. No. 13477

Fig. 26. *Phiomia wintoni* (Andrews).

Portion of left ramus of mandible with symphysis. Amer. Mus. No. 13477. One-third natural size. Upper figure, superior view. Lower figure, external view.

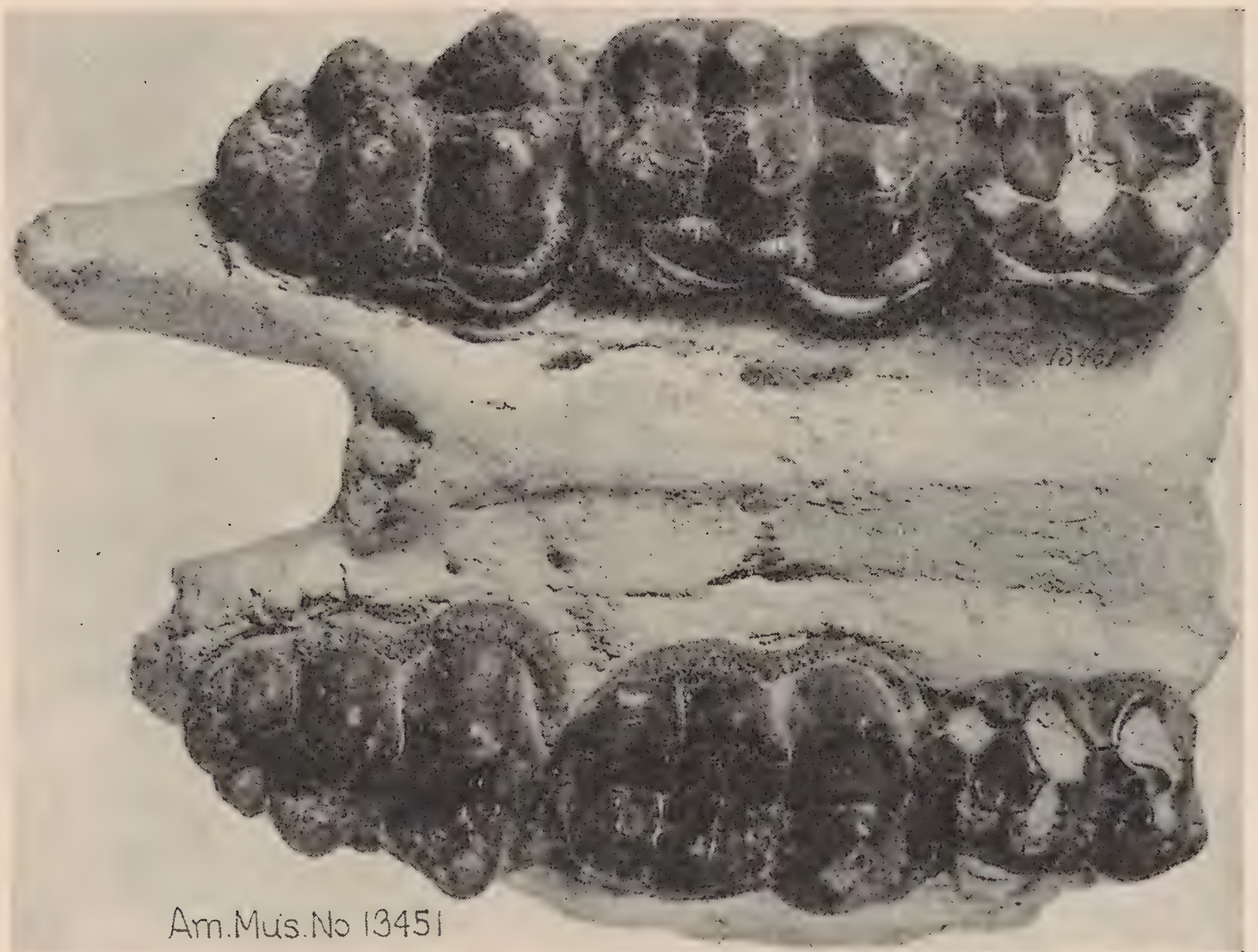


Fig. 27. *Phiomia wintoni* (Andrews).

Portion of skull, including palate. Amer. Mus. No. 13451. One-half natural size. Palatal view.

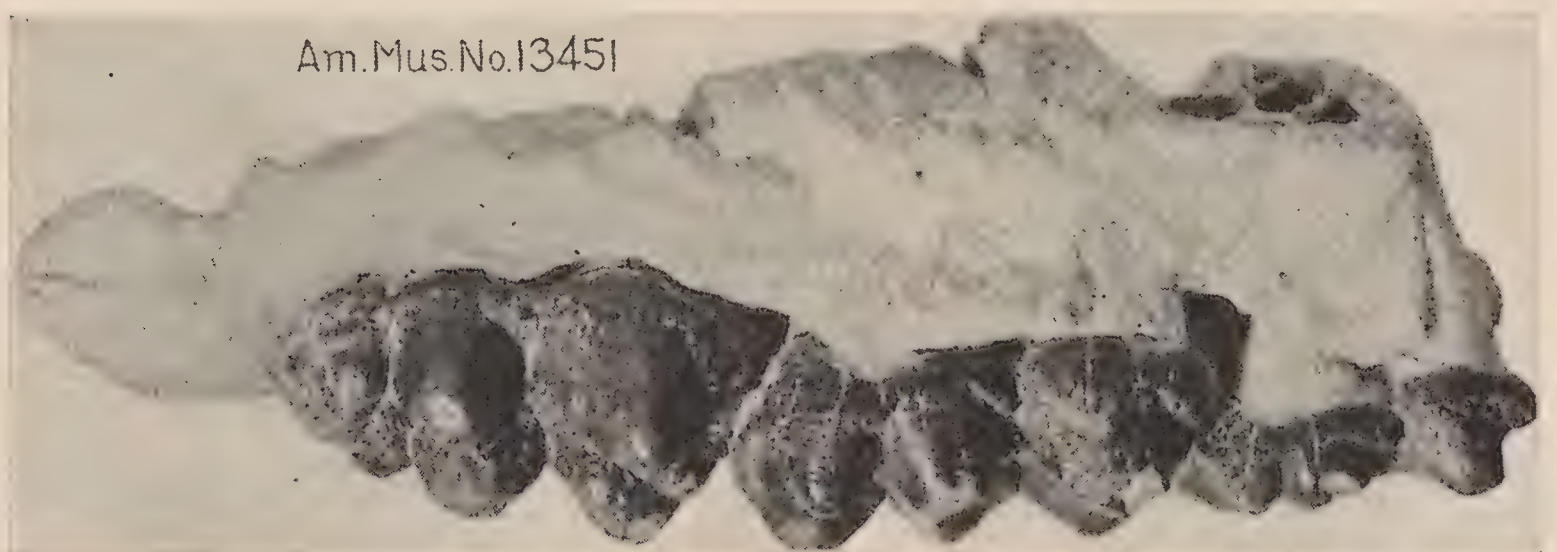


Fig. 28. *Phiomia wintoni* (Andrews).

Palate with molar teeth. Amer. Mus. No. 13451. One-half natural size. External view, right side.

situ; Amer. Mus. Exp. 1907, Quarry A.

No. 13452; a fragment of skull and palate bearing second and third molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry C.

No. 13453; a fragment of skull and palate bearing last premolar and second molar of left side *in situ*, and with alveoli of first molar of the same side; Amer. Mus. Exp. 1907, Quarry B.

No. 13454; a fragment of skull and palate bearing second and third molars of right side *in situ*; Amer. Mus. Exp. 1907, Quarry B.



Fig. 29. *Phiomia wintoni* (Andrews).

Fragment of skull, with second and third right upper molar teeth. Amer. Mus. No. 13492. One-half natural size. Palatal view.

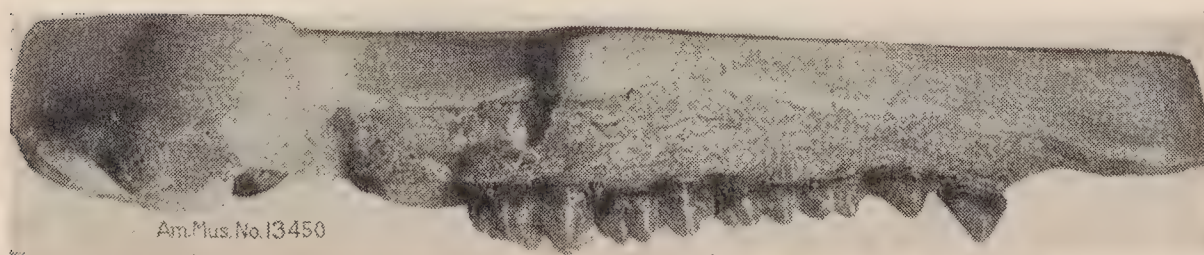


Fig. 30. *Phiomia wintoni* (Andrews).

Portion of skull, with grinding teeth. Amer. Mus. No. 13450. One-sixth natural size. External view, right side.

No. 13456; a fragment of skull and palate bearing last premolar and first and second molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry A.

No. 13457; a fragment of skull and palate bearing all molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry A.

No. 13458; a fragment of skull and palate bearing all deciduous molars and first molar of right side *in situ*, the last-named tooth being just on the way to eruption; Amer. Mus. Exp. 1907, Quarry B.

No. 13459; a fragment of skull bearing last molar of right side *in situ*; Amer. Mus. Exp. 1907, Quarry B.

No. 13460; a fragment of upper jaw bearing right third molar *in situ*, which is much weathered; Amer. Mus. Exp. 1907, north of Qasr-el-Sagha.

No. 13479; a fragment of upper jaw bearing penultimate and last premolars and first molar of left side *in situ*; Amer. Mus. Exp. 1907, Quarry B.

No. 13482; upper anterior and next premolar of left side attached to a fragment of upper jaw; Amer. Mus. Exp. 1907; Quarry B.

No. 13488; a fragment of skull bearing second and third molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry B.

No. 13489; a fragment of skull and palate bearing last premolar and first and second molars of left side *in situ*; Amer. Mus. Exp. 1907, Quarry B.



Fig. 31. *Phiomia wintoni* (Andrews).

Fragment of skull containing second and third molars of the right side Amer. Mus. No. 13493. One-half natural size. Palatal view.

No. 13491; a fragment of skull bearing second molar of left side *in situ*, and with roots of third molar and parts of roots of first molar of the same side; Amer. Mus. Exp. 1907, Quarry B.

No. 13492; a fragment of skull and palate bearing second and third molars of right side *in situ*; Amer. Mus. Exp. 1907, Quarry A.

No. 13493; a fragment of skull and palate bearing second and third molars of right side *in situ*, and with alveolus of first molar of the same side; Amer. Mus. Exp. 1907, Alexandria Trail.

No. 13527; a fragment of skull bearing second and third molars and roots of last premolar and first molar of left side *in situ*; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated right upper third molar; Amer. Mus. Exp. 1907, Quarry A.

Extra Nos.; two isolated left upper third molars; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; a fragment of upper jaw bearing fragmentary left third molar; Amer. Mus. Exp. 1907, Quarry B.



Fig. 32. *Phiomia wintoni* (Andrews).

Portion of left ramus of mandible, with last premolar and first and second molars. Amer. Mus. No. 13494. One-third natural size. Superior view.



Fig. 33. *Phiomia wintoni* (Andrews).

Portion of left ramus of mandible, containing the last premolar and the first molar. Amer. Mus. No. 13484. One-half natural size. External view.



Fig. 34. *Phiomia wintoni* (Andrews).

Portion of left ramus of mandible, containing the last premolar and the first molar. Amer. Mus. No. 13484. One-half natural size. Superior view.

Extra No.; an isolated right upper third molar; Amer. Mus. Exp. 1907, Quarry C.

Extra No.; an isolated right upper third molar; Amer. Mus. Exp. 1907, west of Quarries.

Extra No.; a set of isolated left upper last premolar and first and second molars, all being much weathered; Amer. Mus. Exp. 1907, Quarry B.

Extra Nos.; three isolated upper third molars, two being of right side and one of left side; Amer. Mus. Exp. 1907, Quarry B.

Extra Nos.; two isolated left upper posterior premolars, one of which is fragmentary; Amer. Mus. Exp. 1907, Quarry A.

Extra Nos.; three isolated upper posterior premolars, two being of right side and one of the left side; Amer. Mus. Exp. 1907, Quarry B.



Fig. 35. *Phiomia wintoni* (Andrews).

Fragment of skull and palate containing the last premolar and the first and second molars of the left side. Amer. Mus. No. 13456. One-half natural size. External view, left side.

Extra No.; an isolated right upper penultimate premolar; Amer. Mus. Exp. 1907, 8 miles west of Quarry A.

Extra Nos.; two isolated upper penultimate premolars, one being of right side and the other of left side; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated right upper penultimate premolar; Amer. Mus. Exp. 1907, Quarry C.

Extra No.; an isolated left upper penultimate premolar; Amer. Mus. Exp. 1907, west of Quarries.

Extra No.; a fragment of upper jaw bearing anterior premolar of left side; Amer. Mus. Exp. 1907, 8 miles west of Quarry A.

Extra Nos.; five isolated upper anterior premolars, one of which being of right side and all the rest of the left side; Amer. Mus. Exp. 1907, Quarry B.

Extra No.; an isolated right upper anterior premolar; Amer. Mus. Exp. 1907, west of Quarries.

The following tusks are provisionally referred to this species according to their large size.

- No. 1362¹; a right lower tusk; Amer. Mus. Exp. 1907, Quarry B;
 Extra No.; a fragment of very large right lower tusk; Amer. Mus. Exp. 1907.
 No. 13463; a right upper tusk; Amer. Mus. Exp. 1907, Quarry B;
 No. 13466; a right upper tusk; Amer. Mus. Exp. 1907, west of Quarry A.
 Extra No.; a fragment of left upper tusk; Amer. Mus. Exp. 1907, west of Quarry A.
 Extra No.; a fragment of right upper tusk; Amer. Mus. Exp. 1907, Quarry B.
 All the specimens: Fluvio-marine formation of the Fayûm, Egypt.



Fig. 36. *Phiomia wintoni* (Andrews).

Fragment of skull and palate containing the last pre-molar and the first and second molars of left side. Amer. Mus. No. 13456. One-half natural size. Palatal view.

Andrews considers that the type-specimen of *Phiomia serridens* may belong to a very juvenile individual of a smaller species than *Ph. wintoni*, and probably of *Ph. minor*. The mandibular ramus, symphysis, and lower tusk of the type-specimen of *Ph. serridens* are, of course, much smaller than those of the juvenile mandible of *Ph. wintoni*, illustrated by Andrews in his Pl. xxxii, figs. 1-4, 1908. But it must be reckoned here that the former specimen is much younger than the latter, and that the tusk of the former is evidently a milk-tooth, while that of the latter, I consider, very probably represents a very young stage of the permanent tusk. The proper parts of these two mandibles to be reasonably compared must be only the penultimate milk-molars; and these two teeth of these two mandibles appear to be exactly alike in structure and nearly similar in size, although that of the type-specimen of *Ph. serridens* is only very slightly smaller than that of the other specimen.

¹An error; 1362 refers to a specimen of *Anthracotherium*. 13462 consists of an upper incisor of "*Palæomastodon*." Evidently the reference is to this.—C. C. Mook.

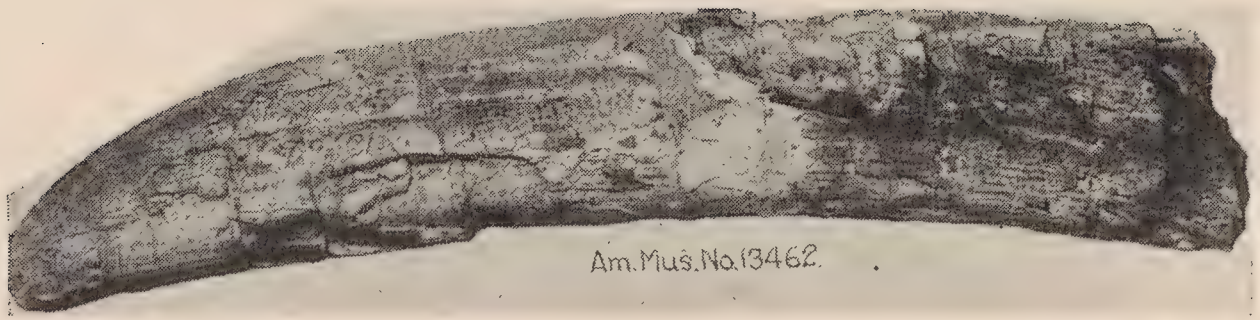


Fig. 37. *Phiomia wintoni* (Andrews).

Right lower tusk. Amer. Mus. No. 13462. One-third natural size. External view.

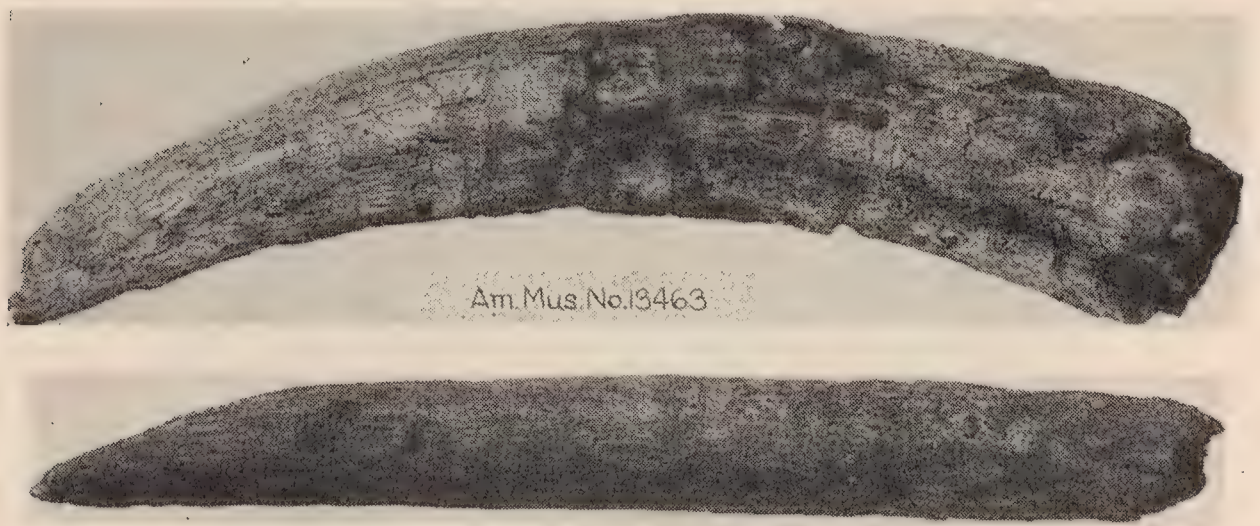


Fig. 38. *Phiomia wintoni* (Andrews).

Right upper tusk. Amer. Mus. No. 13463. One-third natural size. Upper figure, lateral view. Lower figure, superior view.



Fig. 39. *Phiomia wintoni* (Andrews).

Right upper tusk. Amer. Mus. No. 13466. One-half natural size. Upper figure, lateral view. Lower figure, superior view.

Table D

	13470	13474	13476	13477	Andrews			
	Young Prob. ♀	Prob. ♀	Prob. ♀	Prob. ♂	Prob. ♂	Prob. ♀	Prob. ♂	Prob. ♂
Length from Tip of Symphysis to Posterior Side of Angle	470	.....	.....	.....	.....	642	.....	735 ²
Length of Symphysis	152	.....	.....	.....	275 ¹	245	270	273
Length from Tip of Symphysis to Posterior Side of M ₃	.....	.....	.....	.....	545	490	.....	.....
Minimum Antero-posterior Width of Ascending Bar	117	.....	175	.....	.....	.....	.....	185
Maximum Width of Anterior Half of Symphysial Region	76	.....	.....	.....	.....	.....	115	.....
Minimum Width at the Constriction of Symphysial Region	65	.....	.....	.....	80±	80	85	90±
Height of Ramus at P ₃	63	.....	98	.....	.....	.....	.....	.....
Ditto at M ₁	65	95	101	100	.....	.....	.....	.....
Ditto at Anterior Lobe of M ₃	.....	90	93	95	.....	.....	.....	100±
Height of Ascending Bar at Condyle	170	.....	210±a	.....	.....	230	.....	238

¹Misprinted once as "21 cm." and another time as "21.5 cm." in the original reports.

²Misprinted as "45.8 cm." in the original report.

Table E

	13470	13474	13476	13477	13484	13485	13494	ex.	ex.	ex.	ex.	ex.
	Young Prob. ♀	Prob. ♀	Prob. ♀	Prob. ♂		Prob. ♀	Prob. ♂			Prob. ♀	Prob. ♂	
$P_{\overline{3}}$	29	.....	.....	.....	....	.....	.....	.....	....	.....	.....	....
	14.5	.....	.....	.....	....	.....	.....	.....	....	.....	.....	....
$P_{\overline{4}}$	34	.....	36.5	.....	38	.....	40	.....	.....	.....	.....	.....
	24	.....	23	.....	26	.....	25.5	.....	.....	.....	.....	.....
$M_{\overline{1}}$	43	.....	40.5	.....	44	.....	44	.....	.....	.....	.....	43.5
	26	.....	26.5	.....	27	.....	29	.....	.....	.....	.....	29.5
$M_{\overline{2}}$	58	54	56.5	59	....	.....	57	53	60	55.5	.....	....
	33	34	32.5	37	....	.....	36.5	34	36	34	34.5	....
$M_{\overline{3}}$	.....	70	69	77	....	69	.....	.....	.....	.....	.....	.....
	.....	37	38.5	44.5	....	38	.....	.....	.....	.....	.....	.....
Length of P-M	.....	225±	230±	250±	....	.....	.....	.....	.....	.....	.....	.....
Length of M-M	.....	160±	165	.....	....	.....	.....	.....	.....	.....	.....	.....

Table E (Continued)

	Andrews										Andrews		
	Prob. ♀	Prob. ♀		Young Prob. ♂						Very juvenile	Prob. ♂	Very juvenile	Type of <i>Phiomia serridens</i> ; very juvenile ³
P ₃ (Dm ₃)	31	29	...	33	...	...	...	...	...	...	33	36 (29.5) ² (14.5) ²	(27) (13)
	...	...	...	...	...	...	...	...	...	...	20	41	.....
P ₄ (Dm ₄)	34	33	...	40	...	...	...	...	...	(42)	41	(43)	.....
	...	...	...	...	...	...	...	...	...	...	29	(21)	.....
M ₁	39	37	42	51	40	...	...	...	...	...	42	47	.....
	...	...	...	...	...	...	...	...	...	...	30	28	.....
M ₂	53	54	...	[56?] ¹	...	58	57	60	...	...	57	58	.....
	...	...	...	...	...	...	...	...	...	...	39	.....	.....
M ₃	73	...	...	...	...	...	...	...	72	...	71	.....	.....
	...	...	...	...	...	...	...	...	...	...	45	.....	.....
Length of P-M	...	...	...	...	...	...	...	...	...	...	246	.....	.....
Length of M-M	...	...	...	...	...	...	...	...	...	...	173	.....	.....

¹Although this measurement is stated by Andrews as "4.6 cm.," it might perhaps be a misprint for "5.6 cm."
²These measurements were misprinted as "1.95 cm.," and "14.5 cm.," respectively in the original report.
³This specimen bears also Dm₂ *in situ*, which, according to Andrews' statements, measures 12 mm. and 5 mm. in length and width respectively.

Then there may be some probability that the type-specimen of *Ph. serridens* belongs to a very juvenile individual of *Ph. wintoni*. If any definite specific reference of *Ph. serridens* to either *Ph. minor* or *Ph. wintoni* be actually proved, then the specific name “*serridens*” is naturally to replace that of “*minor*” or “*wintoni*,” according to the law of priority. At present, however, our knowledge of *Ph. serridens* is too incomplete to arrive at any definite conclusion about its specific reference.

The mandibles of specimens Nos. 13470, 13474, 13476 and 13477, in comparison with those described and figured by Andrews, measure as indicated, in millimeters, in Table D, p. 35.

The lower cheek teeth at hand, in comparison with those reported by Andrews, are indicated, in millimeters, in Table E, pp. 36–38.

The lower tusks of specimens No. 13462 and extra-number measure as follows (in mm.).

	13462	Ex.
Straight Length, as Preserved.....	250	..
Maximum Longest Diameter.....	44	60
Maximum Shortest Diameter of the Thickening along the Inner Side.....	21	24

The first specimen more or less approaches in its lower tusks of the mandible the specimen No. 13471, which I have just described under *Ph. minor*, in the maximum longest diameter; but it is decidedly longer than it, appearing to me too long to suit to the symphysis of that mandible, so I am inclined to refer the tusk in question not to *Ph. minor*, but provisionally to the present species. It may be possible that this tusk belongs to the female type, and that of the extra number to the male type of the present species. According to Andrews’ statement, the lower tusks of his type specimen measure 52 mm.; those of another mandible, 45 mm.; those of another mandible, 83 mm.; and those of still another mandible, representing a very young stage, 28 mm.¹ The three former of these specimens of Andrews seem to me to belong to the male type. Further, he reported under the present species three isolated lower tusks, which measures 43 mm., 75 mm., and 45 mm. in width respectively.

The fragments of the skulls and palates of specimens Nos. 13450, 13451, 13453 and 13454, in comparison with those described by Andrews, measure as indicated, in millimeters, in Table F. p. 41.

The upper tusks of specimens Nos. 13463, 13466 and extra No. measure as follows (in mm.).

¹This measurement is stated by Andrews as “1.8 cm.” Judging from his figures of this specimen, as well as from his statement of the combined width of the two tusks measuring “6.2 cm.,” it evidently is a misprint for “2.8 cm.”

	13463	13466	ex.
		Prob. ♂	
Straight Length, as preserved.....	250	220	...
Length along Upper Anterior Curve, as preserved.....	278	236	...
Maximum Longest Diameter.....	44	50	43
Maximum Shortest Diameter.....	28.5	31	26

Andrews reported under “*P. beadnelli*” a number of upper tusks, one of which measures 47 mm. and 26 mm.; one, 52 mm. and 35 mm.; and one, 60 mm. and 39 mm. in longest and shortest diameter respectively. At least the second and last ones appear to belong to the male type. Further, he reported one skull of the male type of the present species with upper tusks *in situ* which measure 38 mm. in longer diameter.

The dimensions of the upper cheek teeth at hand, in comparison with those reported by Andrews and by Pontier, are indicated, in millimeters, in Table G, pp. 42–46.

Phiomia osborni, Matsumoto¹

TYPE.—No. 13468; a nearly complete mandible, bearing all the teeth *in situ*; Amer. Mus. Exp. 1907.

Judging from the large premolars and large last molars, as well as from the large symphysial region and tusks, this mandible might belong to a male. It measures as follows, (in mm.).

	13468
	Prob. ♂
Length from Tip of Symphysis to Posterior Side of Angle.....	640
Length of Symphysis.....	275
Length from Tip of Symphysis to Posterior Side of M ₃	510
Minimum Antero-posterior Width of Ascending Bar.....	160
Maximum Width of Anterior Half of Symphysial Region.....	90
Minimum Width of the Constriction of Symphysial Region.....	84
Height of Ramus at P ₃	92
Ditto at M ₁	95
Ditto at Anterior Lobe of M ₃	90
Ditto of Ascending Bar at Condyle.....	210

In comparing this mandible with that of specimen No. 13476, which belongs to the supposed female type of *Ph. wintoni*, one may easily recognize the fact that the former is much larger than the latter in the dimensions of the cheek teeth, while the former is distinctly smaller than the latter in the dimensions of the mandibular ramus behind the

²Amer. Mus. Novitates No. 51, p. 3, 1922.

Table F

	13450	13451	13453	13454	Andrews			
	Prob. ♂	Prob. ♂	Prob. ♀	Prob. ♀	Prob. ♂	Prob. ♀	Poss. ♀	Prob. ♂
Length from Anterior End of Skull to Occipital Condyles	.....	.....	.....	.....	635±a	.....	605	.....
Length of Palate from the Posterior End of Median Suture Line Forward	350	.....	.....	.....	.....	.....	.....	700
Length from Posterior End of Median Suture Line of Palate to Occipital Condyles	.....	.....	.....	.....	.....	.....	260	.....
Bizygomatic Width	377	.....	.....	.....	420	.....	.....	340
Width at External Auditory Openings	.....	.....	.....	.....	322	.....	.....	447
Width Between Inner Ends of Glenoid Fossæ	.....	.....	.....	.....	140	.....	.....	370
Width of Glenoid Fossa	.....	.....	.....	.....	92	.....	.....	.....
Distance Between the Two M ₁	69	67	2×32	.....	.....	.....	.....	97
			=64	.....	.....	.....	75	.....
Ditto Between the Two M ₂	57	53	2×27	2×33	70	.....	.....	.....
			=54	=66		.....	.....	.....
Ditto Between the Two M ₃	47	48	2×28	2×28	.....	.....	.....	.....
			=56	=56	.....	.....	.....	88
Lateral Extension of the Two Occipital Condyles	.....	.....	.....	.....	162	.....	.....	200
Width of Foramen Magnum	.....	.....	.....	.....	63	.....	.....	86
Height from Junction of Basi-occipital and Basisphenoid to Sagittal Crest	.....	.....	.....	.....	220	.....	.....	.....
Height of Foramen Magnum	.....	.....	.....	.....	37	.....	.....	.....

Table G

	13450		13451		13452	13453	13454	13456	13457	13458	13459	13479	13482	13488
	right	left	right	left	Prob. ♂	Prob. ♂	Prob. ♀	Young Prob. ♀	Poss. ♀	Very juvenile Prob. ♀	Prob. ♀	Prob. ♀		Prob. ♀
P ²	37	37	...	...	...	...	...	...	...	...	...	...	35	...
(Dm ²)	22	21	...	...	...	...	...	...	...	(12)	...	...	22.5	...
P ³	34	34	...	...	...	...	...	...	...	(29)	...	33	32	...
(Dm ³)	28	27	...	...	...	...	...	...	...	(20)	...	26	28	...
P ⁴	36	33	...	...	...	...	...	31.5	...	(39)	...	31	...	...
(Dm ⁴)	33	30.5	...	...	...	32.5	...	28.5	...	(25)	...	28	...	...
M ¹	43	43	49	49	...	30	...	42.5	42	42.5	...	42	...	...
M ²	37	32.5	35	35	...	...	...	29	33.5	30	...	30.5	...	...
	49	58	65	65	61	58	59	...	57.5	...	...	...	...	52±
M ³	56	43	46	45	41	39	42	37	43.5	...	...	...	...	38±
	65	64	63	64	60	...	60	...	...	...	62	...	...	60
Length of P-M	47.5	51	46	48	42	...	42	...	45.5	...	43	...	...	43
	265	267	...	...	...	...	...	...	...	...	...	...	...	...
Length of M-M	163	163	168	168	...	...	...	...	158	...	...	...	...	...

Table G (Continued)

	13489	13491	13492	13493	13527	ex.	ex.	ex.	ex.	ex.	ex.
	Prob. ♀	Poss. ♀	Prob. ♀	Prob. ♀	Prob. ♀	Prob. ♂	Prob. ♂	Prob. ♀	Prob. ♂	Prob. ♂	Prob. ♀
P ₂ (Dm ²)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
											
P ₃ (Dm ³)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
											
P ₄ (Dm ⁴)	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.5±
	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.5
M ₁ ¹	39	.....	.....	.....	.....	.....	.....	.....	.....	.....	46±
	31	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.5
M ₂ ²	57	61	54	52	55	.....	.....	.....	.....	.....	54±
	41	42	38.5	40.5	39	.....	.....	.....	.....	.....	37±
M ₃ ³	.....	.....	60	56	60	.....	.....	.....	65	65	.....
	.....	.....	44.5	44	45	.....	.....	.....	46	48	.....
Length of P-M	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Length of M-M	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table G (Continued)

	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.	ex.
P ² ₋																	
(Dm ² ₋)																	
P ³ ₋																	
(Dm ³ ₋)																	
P ⁴ ₋																	
(Dm ⁴ ₋)																	
M ¹ ₋																	
																	
M ² ₋	58	56.5	60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	40.5	40.5±	39.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
M ³ ₋																	
																	
Length of P-M																	
Length of M-M																	

Table G (Continued)

	ex.	ex.	ex.	ex.	ex.	Andrews				
						Prob. ♀	Prob. ♂		Prob. ♀	Prob. ♀
P ² ₋	35	39	36.5	37.5	34	35	40	.....	.....	37
(Dm ² ₋)	23	23	21	21	20.5	21.5	23	.....	.....	.....
P ³ ₋							38	.....	30	.....
(Dm ³ ₋)							29	.....	.....	28
P ⁴ ₋							38	.....	31	34
(Dm ⁴ ₋)							35	.....	.....	32
M ¹ ₋							45	.....	44	45
M ² ₋							34	.....	.....	34
M ³ ₋							61	.....	54	63
Length of P-M							47	.....	.....	43
Length of M-M							61	.....	61	58
							51	.....	.....	44
							284	.....	.....	255±
							170	157	156	155
										145

Table G (Continued)

	Pontier									
	Poss. ♀	Young	Very juvenile	Prob. ♂					Prob. ♂	Prob. ♀
P ²	38	34	(24)	.....	.....	.....	.....	.....	40	.....
(Dm ²)	21	.....	(11)	.....	.....	.....	.....	.....	23	.....
P ³	31	32	(29)	37	36	31	33	.....	33	.....
(Dm ³)	25	.....	(20)	.....	.....	.....	.....	.....	30	.....
P ⁴	32	35	(40)	35	.....	.....	35	33	37.5	.....
(Dm ⁴)	31	.....	(23)	.....	.....	.....	.....	.....	33	.....
M ¹	42	45	.....	48	.....	.....	.....	44	45	.....
M ²	29	.....	.....	.....	.....	.....	.....	.....	36	.....
	56	59	.....	62	.....	.....	.....	.....	60	.....
M ³	40	.....	.....	.....	.....	.....	.....	.....	44	.....
	70	.....	.....	.....	.....	.....	.....	.....	70	57
Length of P-M	47	.....	.....	.....	.....	.....	.....	.....	51	40
	272±	.....	.....	.....	.....	.....	.....	.....	275	.....
Length of M-M	170	.....	.....	.....	.....	.....	.....	.....	167	.....

symphysial region. I especially compared these two mandibles because they are nearly of the same age, as indicated by the almost similar degree of wearing of the cheek teeth. The same relation in size appears to hold true also in the comparison of the present mandible with one described by Andrews and illustrated in his text-fig. 54, which also belongs to the supposed female type of *Ph. wintoni*, though the latter appears to be slightly older than the former. A comparison in size of the present mandible with that of the specimen No. 13476 is made as follows (in mm.).

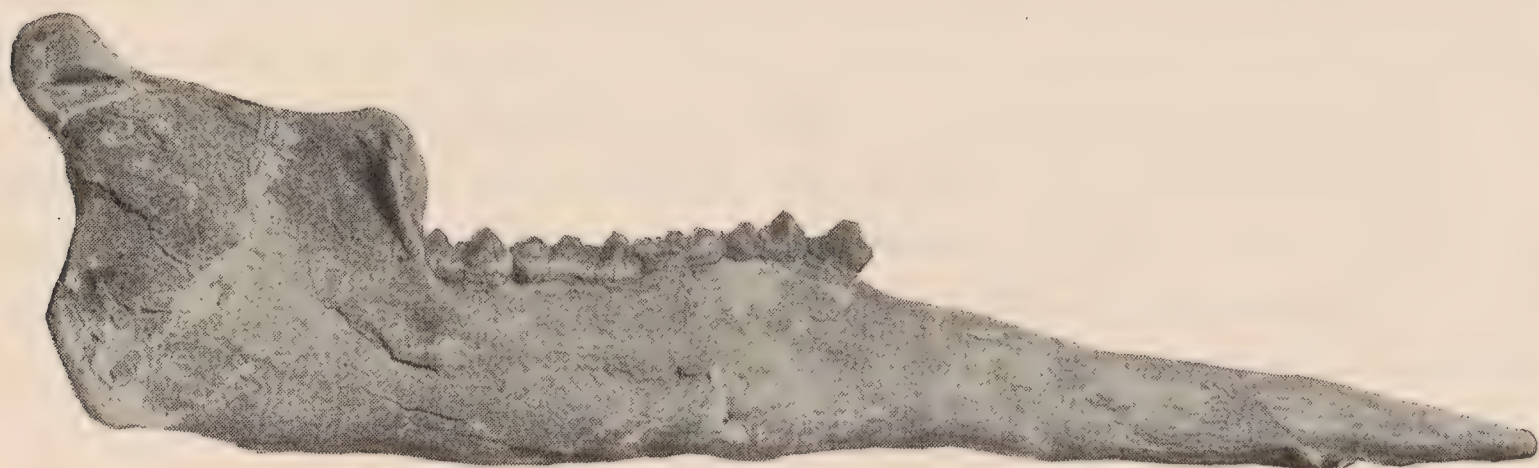


Fig. 40. *Phiomia osborni* Matsumoto.

Original type figure. Type specimen. Amer. Mus. No. 13468. One-seventh natural size.
External view, right side.

	13468	13476
	<i>Ph. osborni</i>	<i>Ph. wintoni</i>
	Prob. ♂	Prob. ♀
Length of Premolar and Molar Series.....	{ 255	
	{ 250	230 ±
Length of Molar Series.....	{ 180	
	{ 177	165
Length from the Anterior Mental Foramen to Posterior Side of Angle.....	450	475
Length from Anterior Side of P ₃ to Posterior Side of Angle.....	395	395 ±
Length from Posterior Side of Symphysial Region to Posterior Side of Angle.....	385	425 ±
Minimum Antero-posterior Width of Ascending Bar.	160	175
Height of Ascending Bar at Coronoid Process.....	163	185
Minimum Height of Coronoid Process.....	158	183
Height of Symphysial Region at Posterior Side of Anterior Mental Foramen.....	67	76
Height of Ramus at P ₃	92	98
Ditto at M ₁	95	101
Ditto at Anterior Lobe of M ₃	90	93

Thus the supposed male type of the present species appears to be smaller than even the supposed female type of *Ph. wintoni* of almost similar age in the size of the mandibular ramus behind the symphysial

region. This species was very probably less bulky than *Ph. wintoni*. If my identification of the sex of this type mandible be erroneous, then the difference of this species from *Ph. wintoni* in dental characters should be much greater than that expected under the present identification.

The left lower tusk of this type mandible protrudes about 58 mm. from the anterior end of the symphysis, and the right one about 83 mm. from the same; the condition seen in the latter might be due to a secondary displacement of the tooth to a certain extent. They measure 47 mm. in longest diameter at base and 20 mm. in shortest diameter of the thickening along the inner side at base. Both the tusks have each a distinct notch at their tips, which might be a result of wearing in digging and rooting plants. These tusks are worn to an extent of 45–55 mm. from tips on the upper surfaces and to an extent of 95–105 mm. from the same along the outer edges.

The cheek teeth of this mandible measure as follows (in mm.).

		13468	
		right—left	
		Prob. ♂	
P ₃	Length	34.5	34
	Width	18.5	17
P ₄	Length	42	43
	Width	27	27
M ₁	Length	44	42
	Width	28	26.5
M ₂	Length	62	62
	Width	35.5	35.5
M ₃	Length	76	73
	Width	41.5	38
Length of P–M		255	250
Length of M–M		180	177

The symphysis extends as far backward as the middle part of the anterior premolars (P₃). At the posterior end of the symphysis there is a prominent median tubercle projected backward; this condition might possibly be unusual.

The lower premolars are comparatively large and long, and the last lower molar is very long and comparatively narrow, though I do not recognize that they are beyond the limit of variation of the lower cheek teeth of the male type of *Ph. wintoni*. The increase in size posteriorly of the series of the cheek teeth seems to be more gradual in this mandible than in the majority of the mandibles of *Ph. wintoni*.

In the last premolar of this mandible, the posterior lobe is distinctly wider than the anterior. *Ph. minor* and *Ph. wintoni* have both types of

the last lower premolar; in one type, the anterior lobe is distinctly wider than the posterior, and in the other type it is just the reverse. In the first molar the posterior lobe is well developed and is almost as wide as, or even slightly wider than, the middle lobe. In almost all the first lower molars at hand of *Ph. minor* and *Ph. wintoni*, the posterior lobe is not so well developed and is distinctly narrower than the middle lobe.

In the second molar of the type, the posterior lobe is very well developed, being distinctly wider than the middle lobe. In all the second lower molars at hand of *Ph. minor* and *Ph. wintoni*, the posterior lobe is much weaker and distinctly narrower than the middle lobe.

The last molar is very long and rather narrow, as already stated, and consists of three lobes and a prominent posterior talon, which forms an imperfect fourth lobe. The posterior talon, or imperfect fourth lobe, consists of two prominent cusps, besides a few smaller crenules. In all the last lower molars at hand of *Ph. minor* and *Ph. wintoni*, the posterior talon is much less prominent than that just observed. The basal cingula of all the molars of this type of mandible are strong, and the intermediate cusps of the same are also well developed.

This species appears to be more progressive than *Ph. minor* and *Ph. wintoni* in the better developed posterior ridge of the first and second lower molars and in the better developed posterior talon of the last lower molar; and to be more archetypal than those species in the more gradual increase in size posteriorly of the lower cheek teeth.

Nothing is yet known about the skull and upper teeth. It is of course possible that some of the fragments of the skulls and some of the upper teeth reported under *Ph. wintoni* may really belong to this species, though it is impossible at present to be certain of this.

III.—SUMMARY AND GENERAL DISCUSSION

VARIATION OF CHEEK TEETH

To show the variation in size of the cheek teeth of *Palæomastodon* and *Phiomia*, I have made a number of graphs. In these graphs the length of the teeth is indicated by asymptote and the width of the same by ordinate. One tooth is represented by one dot. Right and left teeth of the same individual are shown by two dots connected by a line; if the two teeth of the same individual be equal both in length and in width, they are shown only by a single dot.

The disadvantage of this method is due chiefly to the following. (1.) The teeth vary in size according to their age and especially to the degree of wear; for instance, embryonic teeth are smaller than full-

grown teeth, and very heavily worn teeth are smaller than those less worn. This disadvantage is especially serious in M_1^1 , because the range in the degree of wear is extremely great in these teeth. In $M_2^2 \div \frac{3}{3}$, however, this disadvantage is less serious, so far as we admit only one case, that the last lower molar of Andrews's type of *Ph. minor* is embryonic so as to be unusually small. (2.) There are personal errors in taking measurements. This disadvantage might be serious in those branches of study which need strict accuracy, such as human anatomy or physical anthropology. In palæontology, and especially that of large animals like the Proboscidea, such strict accuracy may not be needed, though, of course, the more accurate, the better.

The Indications in the Tables

Blank dots: teeth of *Palæomastodon*.

Black dots: teeth of *Phiomia*.

Round dots: the writer's measurements of the material of the American Museum.

Triangular dots: Andrews's and Pontier's measurements.

A: *Palæomastodon beadnelli*.

B: *Palæomastodon intermedius*.

C: *Palæomastodon parvus*.

D: *Phiomia osborni*.

E: *Phiomia wintoni*.

F: *Phiomia minor*.

m: Supposed male type.

f: Supposed female type.

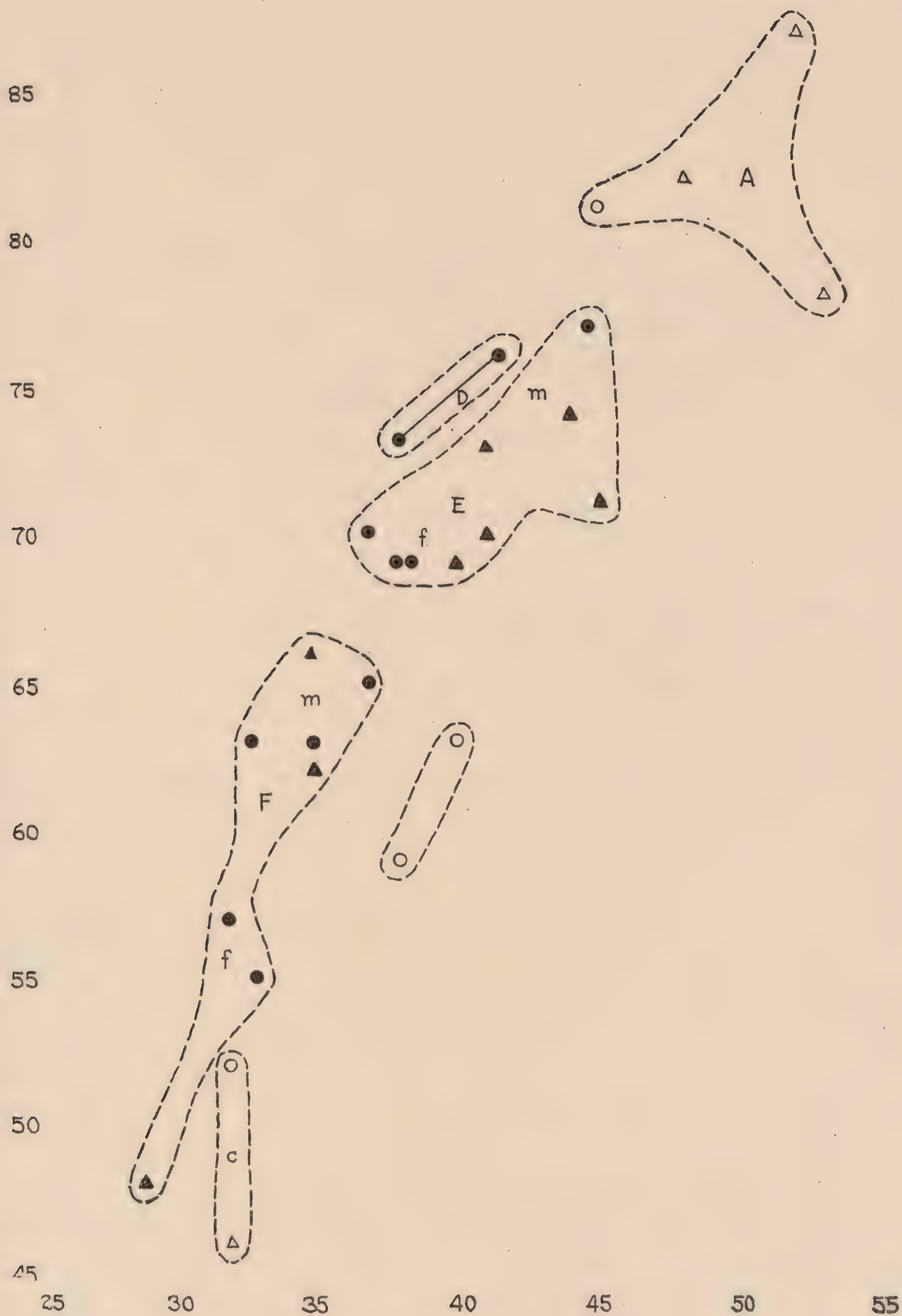


Fig. 41. Diagram indicating variations in size of M_3 .

Blank dots=teeth of *Palaeomastodon*; black dots=teeth of *Phiomia*; round dots=the writer's measurements of the material of the American Museum; triangular dots=Andrews' and Pontier's measurements. A, *Palaeomastodon beadnelli*; B, *Palaeomastodon intermedius*; C, *Palaeomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.



Fig. 42

Fig. 43

Blank dots=teeth of *Palæomastodon*; black dots=teeth of *Phiomia*; round dots=the writer's measurements of the material of the American Museum; triangular dots=Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*. B, *Palæomastodon intermedius*; C, *Palæomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.

Blank dots=teeth of *Palæomastodon*; black dots=teeth of *Phiomia*; round dots=the writer's measurements of the material of the American Museum; triangular dots=Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*. B, *Palæomastodon intermedius*; C, *Palæomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.

45

40

35

30

25

20

25

30

35

Fig. 44

Fig. 44. Diagram indicating variations in size of P_4 .

Blank dots =teeth of *Palæomastodon*; black dots =teeth of *Phiomia*; round dots =the writer's measurements of the material of the American Museum; triangular dots =Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*; B, *Palæomastodon intermedius*; C, *Palæomastodon beadnelli*; D, *Palæomastodon intermedius*; E, *Phiomia wintoni*; F, *Phiomia wintoni*; m, supposed male type; f, supposed female type.

Blank dots =teeth of *Palæomastodon*; black dots =teeth of *Phiomia*; round dots =the writer's measurements of the material of the American Museum; triangular dots =Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*; B, *Palæomastodon intermedius*; C, *Palæomastodon beadnelli*; D, *Palæomastodon intermedius*; E, *Phiomia wintoni*; F, *Phiomia wintoni*; m, supposed male type; f, supposed female type.

70

65

60

55

50

45

30

35

40

45

50

55

Fig. 45

Blank dots =teeth of *Palæomastodon*; black dots =teeth of *Phiomia*; round dots =the writer's measurements of the material of the American Museum; triangular dots =Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*; B, *Palæomastodon intermedius*; C, *Palæomastodon beadnelli*; D, *Palæomastodon intermedius*; E, *Phiomia wintoni*; F, *Phiomia wintoni*; m, supposed male type; f, supposed female type.

Blank dots =teeth of *Palæomastodon*; black dots =teeth of *Phiomia*; round dots =the writer's measurements of the material of the American Museum; triangular dots =Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*; B, *Palæomastodon intermedius*; C, *Palæomastodon beadnelli*; D, *Palæomastodon intermedius*; E, *Phiomia wintoni*; F, *Phiomia wintoni*; m, supposed male type; f, supposed female type.



Fig. 46

Fig. 47

Fig. 46. Diagram indicating variations in size of M^2 .

Blank dots = teeth of *Palaeomastodon*; black dots = teeth of *Phiomia*; round dots = the writer's measurements of the material of the American Museum; triangular dots = Andrews' and Pontier's measurements. A, *Palaeomastodon beadnelli*; B, *Palaeomastodon intermedius*; C, *Palaeomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.

Blank dots = teeth of *Palaeomastodon*; black dots = teeth of *Phiomia*; round dots = the writer's measurements of the material of the American Museum; triangular dots = Andrews' and Pontier's measurements. A, *Palaeomastodon beadnelli*; B, *Palaeomastodon intermedius*; C, *Palaeomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.

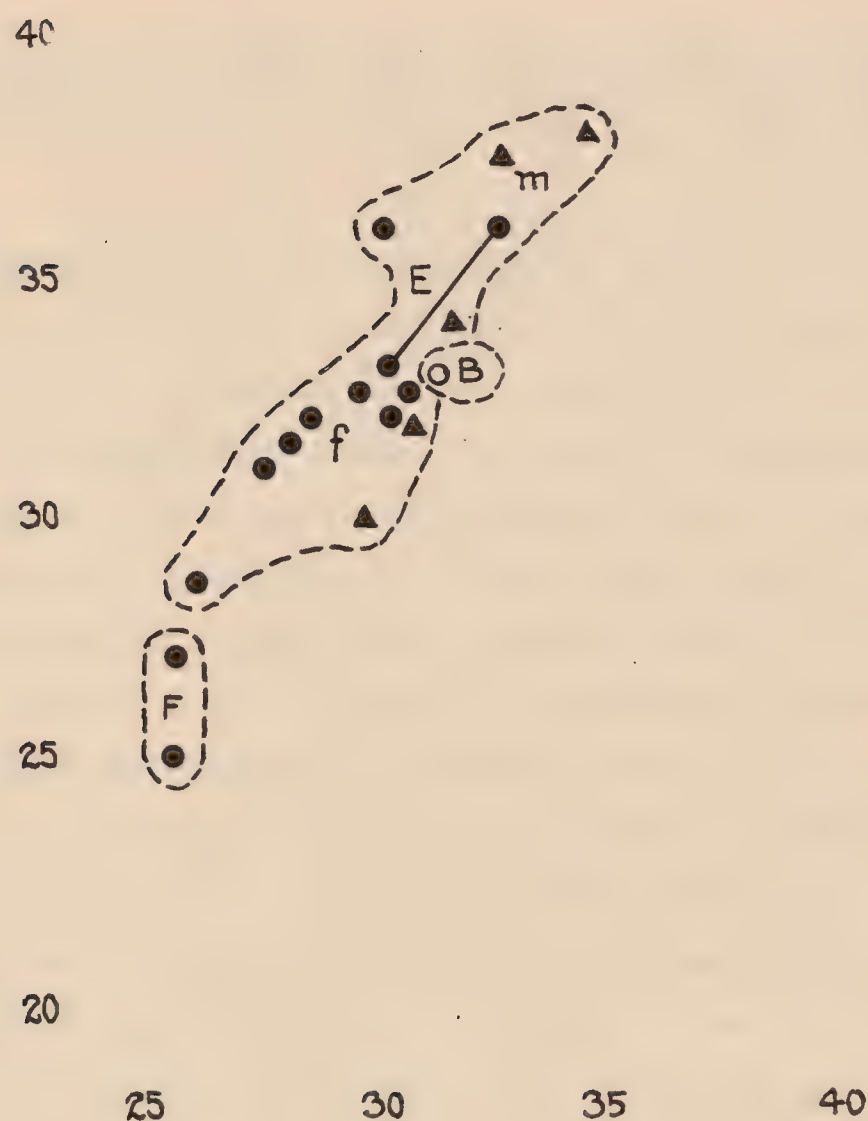


Fig. 48. Diagram indicating variations in size of P^4 .

Blank dots = teeth of *Palæomastodon*; black dots = teeth of *Phiomia*; round dots = the writer's measurements of the material of the American Museum; triangular dots = Andrews' and Pontier's measurements. A, *Palæomastodon beadnelli*; B, *Palæomastodon intermedius*; C, *Palæomastodon parvus*; D, *Phiomia osborni*; E, *Phiomia wintoni*; F, *Phiomia minor*. m, Supposed male type; f, supposed female type.

SUGGESTION AS TO THE PHYLOGENY OF EARLIER PROBOSCIDEA

A number of the differences observed to exist between *Palæomastodon*, as just restricted above, and *Phiomia*, as just revised above, appear to be parallel with those between *Zygodolophodon*-*Mastodon*, s.s., and *Trilophodon*-*Megabelodon*. Further, a number of the characters of *Palæomastodon* in contrast to *Phiomia* appear to be represented also in *Mærittherium*. The more important characters with regard to the present question can be enumerated as follows.

(1.) The skull of *Palæomastodon* is not yet clearly known; but, judging from the shape of the palate, it may probably be more short-skulled than *Phiomia*, which is distinctly long-skulled. The skull of *Zygodolophodon* of the European Vindobonian is not yet clearly known; *Mastodon* is distinctly short-skulled, while both *Trilophodon* and *Megabelodon* are distinctly long-skulled. *Mærittherium* is distinctly short-skulled, quite unlike *Phiomia*.

(2.) The palate of *Palæomastodon* is very wide in comparison with the length of the cheek teeth, while that of *Phiomia* is rather narrow. That of *Zygodolophodon* of the European Vindobonian is not yet known;

that of *Mastodon* is very wide, while those of *Trilophodon* and *Megabelodon* are distinctly narrow. That of *Mærittherium* is neither very wide nor very narrow.

(3.) The mandibular symphysis of *Palæomastodon* appears to be, most probably, rather short, while that of *Phiomia* is very long. That of *Zygodolophodon* of the European Vindobonian is not yet known; that of *Mastodon* is short, while those of both *Trilophodon* and *Megabelodon* are extremely long. That of *Mærittherium* is short.

(4.) The largest and most conspicuous of the anterior mental foramina lies, in *Palæomastodon*, just below the first cheek tooth ($P_{\frac{3}{3}}$) and far back from the posterior end of the symphysis; and, in *Phiomia*, on either side of the symphysial region and far anterior to both the first cheek tooth and the posterior end of the symphysis. In the last-named genus, another smaller one lies just below the anterior cheek tooth. In *Zygodolophodon* of the European Vindobonian, the mental foramina are not yet clearly known; in *Mastodon*, the largest and most conspicuous one of these foramina lies just below the anterior part of the series of the cheek teeth and back from the posterior end of the symphysis, though usually two more foramina, which are smaller, are present anterior to the largest one; while in both *Trilophodon* and *Megabelodon* the condition of the anterior mental foramina is quite similar to that which is observed in *Phiomia*, though the smaller one lies just below the anterior part of the series of the cheek teeth, as the anterior cheek teeth themselves are no more persistent in these genera. In *Mærittherium*, two anterior mental foramina, nearly of equal size, are present on either side of the mandible, either just below the anterior and the penultimate premolars ($P_{\frac{2,3}{2,3}}$) respectively, or just below the penultimate and the last premolars ($P_{\frac{3,4}{3,4}}$) respectively. In many short-jawed mastodonts and elephants, the largest and most conspicuous of the anterior mental foramina lies just below the anterior part of the series of the cheek teeth. The position of the largest and most conspicuous of the mental foramina might be correlated with the development of the symphysial region and lower tusks, probably as well as with the development of the lower lip.

(5.) The cheek teeth of *Palæomastodon* are proportionately shorter and wider than those of *Phiomia*. Those of *Zygodolophodon* and *Mastodon* are also proportionately shorter and wider than those of *Trilophodon* and *Megabelodon*. Those of *Mærittherium* are of proportionately shorter and wider type.

(6.) The cheek teeth of *Palæomastodon* show a lower ridge-formula than those of *Phiomia*. Those of *Zygodolophodon* and *Mastodon* show a

ridge-formula almost similar to those of *Trilophodon*, but a lower ridge-formula than those of *Tetralophodon* and *Megabelodon*. Thus the potentiality of getting a higher ridge-formula was lower in the *Zygalophodon-Mastodon* phylum than in the *Trilophodon-Megabelodon* phylum. The cheek teeth of *Mærittherium* show a lower ridge-formula even than those of *Palæomastodon*.

(7.) The cheek teeth of *Palæomastodon* are bunolophodont, attaining a typically lophodont feature when moderately worn; while those of *Phiomia* are typically bunodont. Those of both *Zygalophodon* and *Mastodon* are lophodont; while those of *Trilophodon*, *Tetralophodon*, and *Megabelodon* are bunodont. Those of *Mærittherium* are bunolophodont, attaining a typical lophodont feature when moderately worn.

(8.) In the cheek teeth of *Mærittherium*, *Palæomastodon*, *Zygalophodon* and *Mastodon* no trefoil pattern of cusps is developed; while in those of *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon* a trefoil pattern of cusps is well developed.

(9.) In the cheek teeth of *Mærittherium*, *Palæomastodon*, *Zygalophodon*, and *Mastodon* the ridges are not very thick antero-posteriorly, the valleys are widely open, and even the walls and bottoms of the valleys are worn since very early stages of wearing; while in those of *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon* the ridges are very thick antero-posteriorly, the valleys are not so widely open, and the worn surface is almost even.

(10.) In the cheek teeth of *Mærittherium*, *Palæomastodon*, *Zygalophodon*, and *Mastodon*, the surface of the enamel is rather smooth; while in those of *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon* the same is very rough.

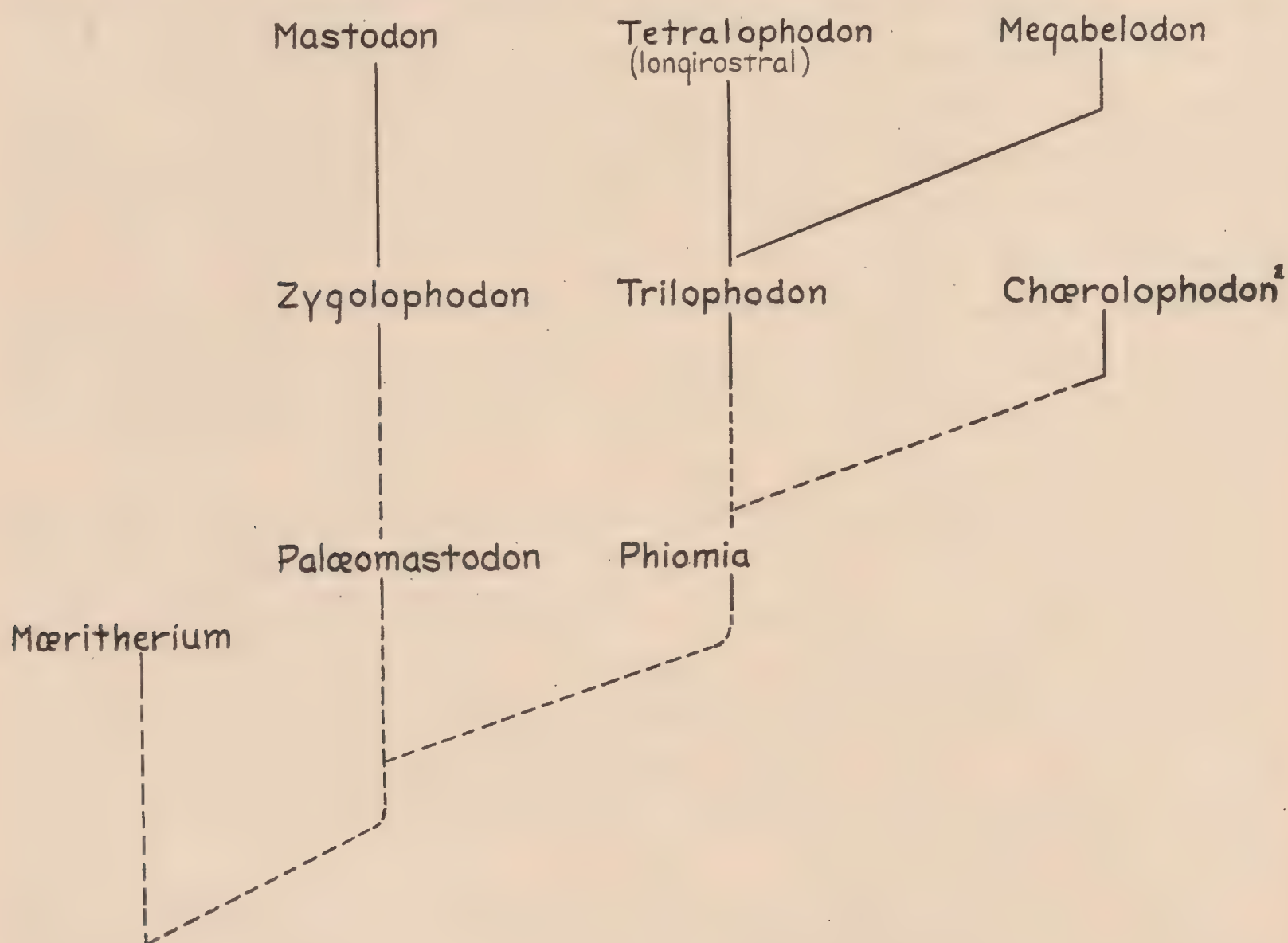
(11.) The basal cingula of the cheek teeth are more or less strong in *Mærittherium*; rather feeble in *Palæomastodon*, *Zygalophodon*, and *Mastodon*; and very strong and rough in *Phiomia*, *Trilophodon*, *Tetralophodon*, and *Megabelodon*.

Judging from these facts, *Phiomia* appears to me to have nothing to do with the ancestry of the *Zygalophodon-Mastodon* phylum, while *Palæomastodon* appears nearly to correspond to a theoretical ancestral type of this phylum.

Again, judging from these facts and others, *Palæomastodon* stands structurally between *Mærittherium* and *Phiomia*. Then, do the three genera, *Mærittherium*, *Palæomastodon* and *Phiomia*, form together a fair evolutionary phylum? It is their stratigraphical occurrence that is against such a view, the first occurring in both the Qasr-el-Sagha and

the overlying Fluvio-marine formations, and both the second and third occurring only in the Fluvio-marine formation. If I judge aright, *Mæritherium* might represent the first wave of earlier proboscidian dispersal which arrived in the districts of the Fayûm, while both *Palæomastodon* and *Phiomia* may represent the second wave of the same. Such an explanation is in harmony with the view that *Mæritherium* might correspond to a slightly altered descendant of an ancestral type, or a close ally of an ancestral type, of *Palæomastodon*, and *Palæomastodon* might correspond to a little altered descendant of an ancestral type, or a close ally of an ancestral type, of *Phiomia*. *Mæritherium* itself appears not to have yielded its successor, while *Palæomastodon* and *Phiomia* appear to correspond just to the beginnings of the two very great phyla, namely the *Zygalophodon-Mastodon* phylum and the *Trilophodon-Megabelodon* phylum (*Trilophodon-Tetralophodon* phylum in the Old World), respectively.

In my opinion, the phylogenetic relationship of the genera just referred to, can be diagrammatically shown as follows:



¹This genus is practically a *Trilophodon* with polymastodont cheek teeth; besides the genotype "*Mastodon*" *pentelici* of Pikermi of Greece and Maragha of Persia, it appears to me also to include "*Mastodon*" *pandionis* of the Gaj and Lower Siwaliks of India, as well as of China. The Gaj form was once erroneously stated as "*Mæritherium*?" by Pilgrim.

Article II.—THIRD CONTRIBUTION TO THE SNAKE CREEK FAUNA

By W. D. MATTHEW

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This article is based upon the results of the American Museum Expeditions of 1918, 1921 and 1922 in charge of Albert Thomson. Large additions to the collection from these quarries were made by these expeditions, and studies of the stratigraphy and faunas of the different quarries and pockets showed that three distinct faunal zones were present, each now represented by large collections. The writer spent a part of the summer of 1922 with the party at the Snake Creek quarries and revised and extended the stratigraphic observations of previous years.

STRATIGRAPHY OF THE SNAKE CREEK QUARRIES

The relations between the "Snake Creek," and "Sheep Creek" beds had not been clearly understood. The former appeared when first examined to be a distinct and later formation overlying the eroded surfaces of the latter. A more careful study of the quarry cuts and faunas makes it necessary to modify this conclusion to some extent, the two representing different facies of the same formation or sequence of strata, in part contemporaneous, rather than two distinct formations. The Snake Creek beds are channel-fillings throughout (except near the top), and they fill and overlie eroded channels in the Sheep Creek beds,

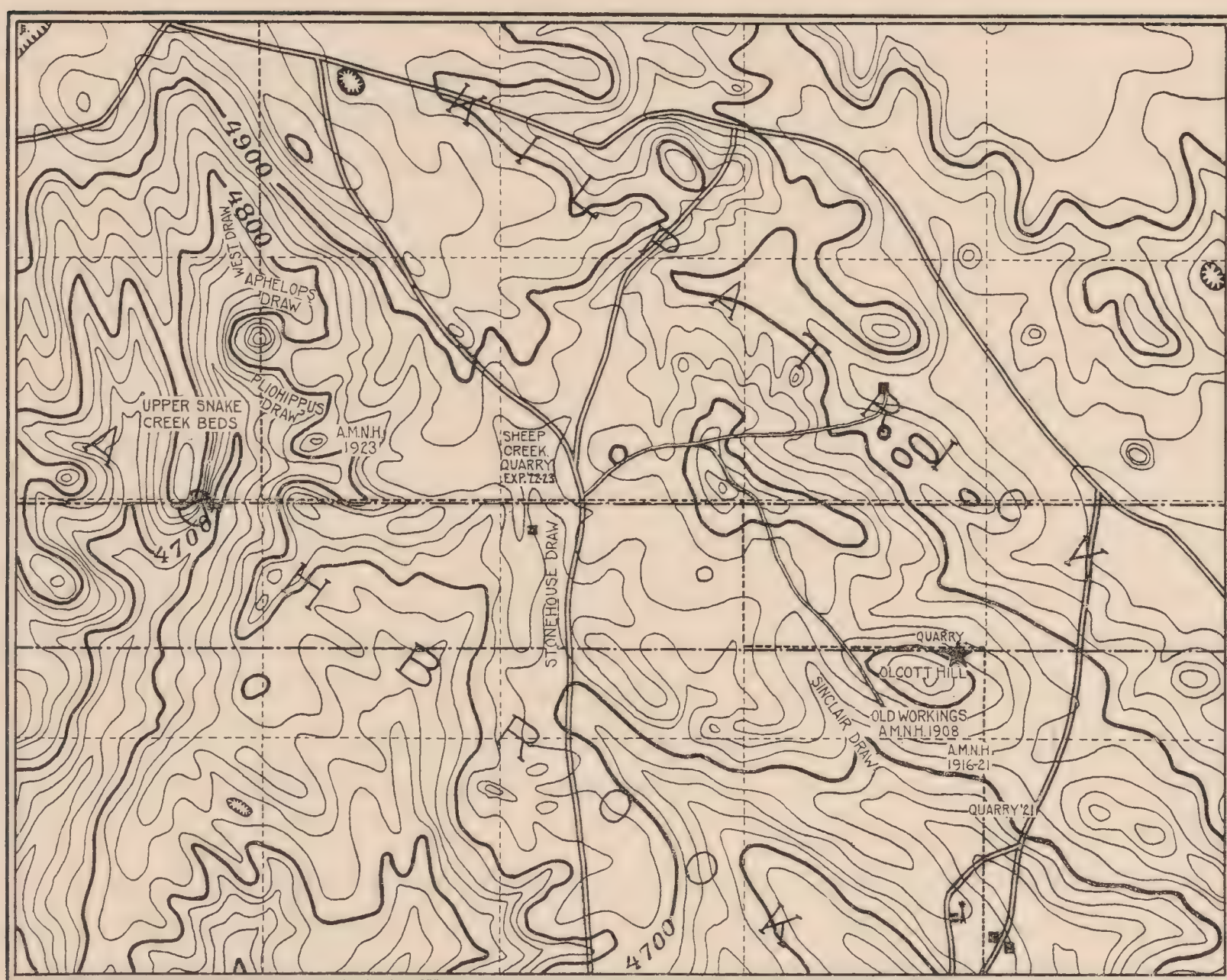


Fig. 1. Snake Creek quarries, Sioux Co., Nebraska.

Scale approximately four-fifths inch to the mile. The contours are from the U. S. Geol. Survey map and are far from accurate. The dotted squares are section lines. The star at Olcott Hill shows the quarry from which the *Hesperopithecus* tooth was obtained by Harold J. Cook.

In 1922-3 some collecting was done in the *Aphelops* and *Pliohippus* draws, but the principal collection made is from a channel-bed in Stonehouse draw containing the *Merychippus primus* fauna.

The principal collecting localities for the different faunal zones and phases are as follows:

	CHANNEL-BED PHASE	FLOODPLAIN PHASE
	Olcott hill*	
	<i>Pliohippus</i> draw	
<i>Hipparion affine</i> zone	<i>Merychippus</i> draw	[None recognized]
	<i>Aphelops</i> draw	
	West draw	
<i>Merychippus paniensis</i> zone	Sinclair draw*	Olcott hill
		<i>Merychippus</i> draw*
		<i>Pliohippus</i> draw
<i>Merychippus primus</i> zone	Stonehouse draw*	Olcott hill
		<i>Aphelops</i> draw
		<i>Merychippus</i> draw
		etc.

The four starred localities are the most important.

dently undercut an overhanging bank of the Miocene formation, which has tumbled down in large blocks, the interspaces between which are filled up with coarse sand, pebbles and fossil teeth and bones. Overlying these unmistakable channel-beds are uniform fine, clear sands of eolian type, showing eolian cross-bedding very distinctly at one point, and capped by sod. Traces of old sod surfaces whose position and slope is wholly unrelated to the present topographic detail, were uncovered by some of the excavations in this uppermost member of the Mio-Pliocene sequence. As is usual beneath any persistent sod surface that overlies an unconsolidated formation, the uppermost foot or two of sand has been compacted and consolidated by the mineral residuum from ground water rising to the surface and evaporating. This residuum, forming a calcareous cement, aids greatly in stiffening the sod and helps it to resist erosion. It is evident in some of the old sod-lines noticed above. Corresponding conditions in a much more clayey formation have been pointed out by Sinclair as the probable significance of the "nodule layer" in the *Oreodon* beds of the South Dakota Brule and of similar concretionary layers elsewhere.

The series of little draws in which the quarries are situated were named by our party for convenient reference, beginning at the west end where the Mitchell-Agate road crosses the fence between the Ashbrook and Kilpatrick ranches: West draw, *Aphelops* draw, *Merychippus* draw, West *Pliohippus* draw, East *Pliohippus* draw, Stonehouse draw, West and East Sinclair draw, Olcott hill. The last two localities are in the Ashbrook ranch, the others in the Kilpatrick ranch. We are indebted to the courtesy of the Kilpatrick Brothers of Beatrice, Nebraska, for free permission to collect upon their land, especially in 1918, 1922 and 1923; and to Mr. Harry Ashbrook for permission to collect in the seasons of 1916 and 1921.

The occurrence of the fossiliferous beds in the different draws is shown diagrammatically in Fig. 1. The earlier collecting in 1908 was mainly picking up of surface material, a couple of small pockets in Sinclair draw being opened up. In 1914 the principal collecting locality of the Princeton party (loc. 1000C) was in this draw; and most of the material secured by the American Museum expedition of 1916 also came from a branch of Sinclair draw. In 1918 Mr. Thomson's principal collecting was from quarries in *Aphelops* draw. The type skeleton of *Pliohippus leidyanus* was obtained by H. J. Cook from East *Pliohippus* draw. In 1921 the American Museum party opened three quarries, two (Quarries A and B) in a branch of Sinclair draw, the third (Quarry C) on Olcott hill, the locality where Mr. Cook found the type of *Hesperopithecus*.

which are rather a fine-grained uniform backwater or floodplain formation. But the stratigraphic and faunal evidence jointly show that the floodplain beds are contemporary with at least the two older horizons (Miocene) of the channel beds. The third faunal horizon of the channel-beds has no recognized floodplain correlative; and the capping of the whole formation is certainly in part, and presumably as a whole, a dune-sand of Pliocene age.

The exposures of the Snake Creek and Sheep Creek lie at the heads of a number of "draws," which drain down into Dry Spotted Tail Creek, thence into the North Platte River. The locality is some twenty miles south of Agate and about the same distance north of Mitchell. These gullies are on the south margin of the sand-hill strip that separates the Niobrara from the North Platte drainage, on the south side of a series of small rounded hills that extend in a S. E.-N. W. direction for three miles or more. These small hills are of typical sand-hill contour, but appear to be of Pliocene age, whereas the sand-hills surrounding them are regarded as Pleistocene or sub-recent in their contouring and in the occasional fossils found in them.

The working hypothesis adopted is that the Snake Creek beds are channel and floodplain deposits of the North Platte river at a time when the valley was at a considerably higher level than now. The Oligocene and Miocene formations of this region were deposited as broad sheets or, more exactly, as wide, thin, flat lenses of floodplain deposits, broadly overlapping but not constituting a continuous column in any one locality, the area of floodplain deposition being shifted to and fro as the streams changed their courses, and the deposition varying in rate, reduced to a minimum or wholly discontinued for considerable intervals. These extended floodplain deposits were traversed by channel-beds of coarser and cleaner sand, mud-balls and small pebbles. At certain points, probably due directly or indirectly to the existence of persistent pools or springs that served as waterholes for the animals, fossil bones and teeth are abundant but nearly always dissociated, much broken and often waterworn. They are much scarcer in the backwater or floodplain deposits but frequently associated, often articulated and more or less complete skeletons, although in many cases considerably damaged by subærial weathering before burial.

The backwater deposits indicate continuance of sedimentation in this area until toward the end of the Miocene. The *Hipparion* and *Pliohippus* fauna, of Pliocene age, is found in channel-fillings cut down to perhaps fifteen or twenty feet below the highest adjacent exposures of the Miocene floodplain strata. At one or two points the channel evi-

LIST OF VERTEBRATE FAUNA FROM THE SNAKE CREEK AND SHEEP CREEK

		Sheep Creek <i>Merychippus primus</i> Zone	Lower Snake Creek <i>M. paniensis</i> Zone	Upper Snake Creek <i>Hipparion affine</i> Zone
PRIMATES				
<i>Hesperopithecus haroldcookii</i>	upper molar tooth ¹			×
CARNIVORA				
<i>Hyænognathus direptor</i>	2 lower jaws; upper teeth			×
<i>Ælurodon sævus</i>	upper and lower jaws, etc.			×
“ <i>haydeni</i>	“ “ “ “ “			×
<i>Tomarctus brevirostris</i>	3 skulls, many jaws, etc.		×	
“ <i>temerarius</i>	jaws and teeth		×	
“ <i>confertus</i>	skull, several jaws		×	
“ <i>optatus</i>	upper and lower jaws, skull	×		
“ <i>mortifer</i>	“ “ “ “		×	
“ sp.	jaw fragments, teeth			×
<i>Amphicyon idoneus</i>	upper jaw, skull, etc.	×		
“ <i>frendens</i>	upper and lower jaws, teeth, etc.	×		
“ <i>sinapius</i>	skull, jaws, etc.		×	
“ <i>gigas</i>	part of lower jaw, teeth		×	
<i>Pliocyon medius</i>	skull, jaws, etc.		×	
“ ? sp.	jaw fragments, teeth			×
<i>Probassariscus antiquus</i>	part of lower jaw		×	
<i>Hyænarctus</i> sp.	teeth			×
<i>Leptocyon vafer</i>	lower jaws		×	
<i>Euoplocyon prædator</i>	lower jaw		×	
<i>Leptarctus primus</i>	skull, jaws		×	
<i>Brachypsalis matutinus</i>	upper and lower jaws	×		
“ <i>modicus</i>	“ “ “ “		×	
“ <i>obliquidens</i>	lower jaw		×	
“ <i>pristinus</i>	lower jaw, upper jaw			×
<i>Mionictis incertus</i>	jaws, teeth, etc.		×	
“ <i>elegans</i>	“ “		×	
<i>Plionictis glareæ</i>	“ “		×	
“ <i>parviloba</i>	“ “		×	
<i>Sthenictis dolichops</i>	“ “ “		×	
“ sp.	“ “			×
<i>Pseudælurus intrepidus</i>	“ “ “		×	
<i>Heterofelis catocopis</i>	lower jaw			×

LIST OF VERTEBRATE FAUNA FROM THE SNAKE CREEK AND SHEEP CREEK—Continued

		Sheep Creek <i>Merychippus primus</i> Zone	Lower Snake Creek <i>M. paniensis</i> Zone	Upper Snake Creek <i>Hipparion affine</i> Zone
GLIRES				
<i>Mylagaulus novellus</i>	jaws	×		
“ <i>vetus</i>	skulls, adult and young; jaws	×		
“ <i>lævis</i>	skull, jaws, and teeth		×	
“ <i>paniensis</i>	jaws and teeth		×	
“ <i>sesquipedalis</i>	“ “ “			×
“ <i>monodon</i>	“ “ “			×
<i>Ceratogaulus rhinocerus</i>	palate, jaws, teeth		×	
<i>Dipoides tortus</i>	upper and lower jaws			×
“ <i>curtus</i>	“ “ “ “		×	
<i>Amblycastor fluminis</i>	lower jaws, teeth		×	
<i>Thomomys</i> sp.	“ jaw			×
<i>Peridiomys rusticus</i>	“ jaws		×	
<i>Poamys rivicola</i>	“ “		×	
<i>Sciurus aberti</i>	“ jaw			×
<i>Lepus vetus</i>	“ jaws		×	
EDENTATA				
<i>Megalonyx curvidens</i>	teeth			×
INSECTIVORA				
<i>Talpa incerta</i>	lower jaw		×	
<i>Scalops</i> cf. <i>aquaticus</i>	“ jaw			×
PERISSODACTYLA				
<i>Chalicotheriid</i> , gen. indesc.	molar; phalanges	×		
<i>Aphelops megalodus</i>	jaws, fragmentary skeleton	×	×	
“ cf. <i>crassus</i>	upper and lower jaws, etc.			×
“ <i>mutilus</i>	skull, skeleton bones			×
<i>Peraceras</i> sp.	jaws, foot bones			×
<i>Teleoceras medicornutus</i>	“ teeth, skeleton bones	?	×	
“ cf. <i>fossiger</i>	“ “ and bones			×
<i>Hypohippus affinis</i>	parts of jaws, teeth, etc.			×
“ <i>osborni</i>	“ “ “ “ “		×	
“ <i>pertinax</i>	upper and lower jaws, teeth	×	×	
<i>Archæohippus penultimus</i>	lower jaw, teeth	×		
<i>Parahippus integer</i>	upper and lower jaws, teeth		×	
<i>Merychippus primus</i>	skulls, many jaws, etc.	×		
“ <i>paniensis</i>	“ “ “ “		×	

LIST OF VERTEBRATE FAUNA FROM THE SNAKE CREEK AND SHEEP CREEK—Continued

		Sheep Creek <i>Merychippus primus</i> Zone	Lower Snake Creek <i>M. paniensis</i> Zone	Upper Snake Creek <i>Hipparion affine</i> Zone
<i>Merychippus sejunctus</i>	palates, jaws, etc.		×	
“ <i>proparvulus</i>	“ “ “		×	
“ <i>campestris</i>	“ “ “		×	
“ <i>eohipparion</i>	“ “ “		×	
<i>Protohippus perditus</i>	jaws, teeth, etc.			×
“ <i>placidus</i>	“ “ “			×
<i>Pliohippus leidyanus</i>	skeleton, skull, jaws, etc.			×
“ cf. <i>supremus</i>	jaws, teeth, bones			×
“ cf. <i>mirabilis</i>	“ “ “			×
“ cf. <i>nobilis</i>	teeth, foot bones			×
<i>Hipparion affine</i>	jaws, teeth, etc.			×
“ <i>occidentale</i>	“ “ “			×
“ <i>gratum</i>	“ “ “			×
“ sp. div.	“ “ “			×
ARTIODACTYLA				
Dicotylid gen. indet.	fragmentary upper jaw	×		
<i>Prosthennops serus</i>	parts skull, jaws, etc.			×
“ <i>crassigenis</i>	jaws, teeth, etc.			×
“ sp.	jaw fragments		×	
<i>Merychyus</i>	jaws, etc.	×	×	
<i>Metoreodon relictus</i>	palate, jaws, etc.		×	
“ <i>major</i>	upper and lower jaws			×
<i>Pronomotherium siouense</i>	skull, jaws, etc.	×	×	
<i>Miolabis tenuis</i>	lower jaws, skull, etc.	×		
“ <i>fissidens</i>	upper and lower jaws, etc.		×	
<i>Protolabis pusillus</i>	lower jaws, etc.	×		
“ <i>saxeus</i>	skull, jaws, etc.	×		
“ <i>angustidens</i>	“ “	×	×	
<i>Alticamelus priscus</i>	skull, jaws, etc.	×		
“ <i>leptocolon</i>	“ “ “		×	
“ <i>procerus</i>	skeleton, jaws, etc.		×	?
“ sp. div.	jaws, etc.			×
<i>Megatylopus gigas</i>	skull, jaws, etc.			×
? <i>Procamelus</i> cf. <i>gracilis</i>	parts of jaws, teeth, etc.			×
<i>Blastomeryx medius</i>	upper and lower jaws, etc.	×		
“ <i>elegans</i>	“ “ “ “		×	
“ <i>wellsi</i>	parts of jaws, etc.			×

LIST OF VERTEBRATE FAUNA FROM THE SNAKE CREEK AND SHEEP CREEK—Continued

		Sheep Creek <i>Merychippus</i> <i>primus</i> Zone	Lower Snake Creek <i>M. paniensis</i> Zone	Upper Snake Creek <i>Hipparion affine</i> Zone
<i>Dyseomeryx riparius</i>	upper and lower jaws	×		
“ <i>sinclairi</i>	skull, jaws, etc.		×	
“ sp.	parts of jaws, etc.			×
<i>Merycodus necatus</i>	skulls, many jaws, etc.	×	×	
“ <i>altidens</i>	teeth, etc.			×
<i>Cranioceras unicornis</i>	occiput, ? jaws, etc.		×	
<i>Neotragocerus improvisus</i>	horn ? jaws			×
<i>Drepanomeryx falciformis</i>	? horn		×	
AVES				
<i>Geranoaëtus contortus</i>	metatarsi, metacarpi, etc.		×	
“ <i>conterminus</i>	metatarsi			×
<i>Urubitinga enecta</i>	tibia, humerus, radii, etc.	×		
<i>Aquila</i> sp.	part of radius		×	
<i>Buteo typhoius</i>	metatarsus, etc.		×	
<i>Ortalis phengites</i>	humerus			×
CROCODILIA				
<i>Alligator thomsoni</i>	skull, jaws, etc.	×	×	×
CHELONIA				
<i>Testudo</i> cf. <i>orthopygia</i>	many complete or broken shells		×	×
“ <i>orth.</i> var.	“ “ “ “ “	×		
<i>Platypeltis miocænus</i>	carapace complete		×	
<i>Chelydrops stricta</i>	skull, etc.		×	
AMPHIBIA				
<i>Plicagnathus matthewi</i>	part of lower jaw		×	
PISCES				
Silurid, large, indet.	parts of skull, jaws, etc.	×	×	
Centrarchid cf. <i>Micropterus</i>	part of skull, ? vertebræ		×	
Pisces div. indet.	miscellaneous fragments	×	×	×

DISTINCTIONS BETWEEN THE FAUNAL ZONES

When this fauna was discovered in 1908 it was supposed to represent a single faunal horizon. The fauna when studied was necessarily referred to the Lower Pliocene, on account of the presence of a series of typically Pliocene mammals, but a large part of the collection consisted of Middle

or Upper Miocene species whose presence in this fauna was explained as a survival.

Dr. J. C. Merriam, in connection with his correlation work upon the later Tertiary faunas of the Pacific coast, found that in that region the Miocene and Pliocene faunas were clearly separate in time, and that no such survival occurred of characteristic Miocene genera into the Pliocene. He suggested that the apparent association at Snake Creek might be due to the confusion of two distinct faunal horizons. A reëxamination of our material suggested that this explanation might be tenable, since there appeared to be certain differences in the preservation of the material referable to the older and younger faunal stages, the latter tending to be more water-worn, more broken up, harder and more heavily silicified and of a brownish-black color as compared with the prevalent blue-black tinge seen in the older faunal elements.

Merriam's suggestion was provisionally accepted but no field observations were made to verify it until 1918. Mr. Thomson's observations and collecting during that season placed the matter beyond question. Further observations were made by Thomson in 1921-1923 and by the writer in 1922.

As is shown in the preceding list, the Miocene faunæ are quite distinct from the Pliocene faunæ. A few species appear to pass through unchanged but these exceptions may be due in some cases to the accident of re-deposit, in some others to our imperfect knowledge of the species in one or both horizons. The uppermost, or fourth fauna, is by no means clearly distinguished.

The most important distinction is in the Equidæ, these being by a wide margin the most abundant fossils in each horizon. *Merychippus* is the principal genus of the two older faunæ. *Parahippus* and *Hypohippus* are scarce. In the third fauna *Hipparion* and *Pliohippus* are abundant, *Protohippus* rather scarce and *Hypohippus* rare. The fourth fauna is doubtfully characterized by predominance of large, progressive *Pliohippus*, *Peraceras* and *Megatylopus*. A few jaw fragments and teeth of *Merychippus* have been found with the collections from the *Hipparion* zone quarries, but these may be due to re-deposit or, in certain instances, to error in field records. *Parahippus* is not found. The distinction in adult teeth between progressive species of *Merychippus* and primitive species of the three later genera is not so sure and easy as one might suppose from the statements made by various writers, but the milk premolars are more clearly distinguishable, those of *Merychippus* much broader and lower-crowned and imperfectly cemented, while in the

three Pliocene genera they are higher-crowned, narrower and heavily cemented at a much earlier ontogenetic stage. Out of some thousands of jaws and teeth of the milk dentition all that I have seen in the older beds are unmistakably *Merychippus*,¹ while that type is entirely absent in the later fauna and all the teeth are of the later type.²

The camels are not so clearly distinct, but in the older faunæ we find the smaller types of giraffe-camel (*Alticamelus*) abundant and with them a smaller number of *Miolabis* (brachyodont camels, mostly split-foot). In the later faunæ we find species of giraffe-camel, mostly of larger size, and with them the gigantic *Megatylopus*.

Third in point of abundance is *Merycodus*, very common in the lower levels and mostly referable to *M. necatus*. The genus is much scarcer in the upper fauna and is represented chiefly by larger species, some of which may prove when better known to belong to distinct genera more nearly related to *Antilocapra*.

The Carnivora, especially the Canidæ, show well-marked distinctions. The typical Canidæ in the lower levels belong mostly to *Tomarctus*, and *Ælurodon* is absent. In the upper level *Ælurodon* is the common form and *Tomarctus* is doubtfully represented by fragmentary material. Amphicyonine dogs are represented by *Amphicyon* and *Pliocyon* in the lower levels; in the upper the material is too fragmentary for certain allocation but the species appear to be distinct.

The rhinoceroses of the three faunæ are probably distinct but their comparative scarcity and lack of complete skulls makes the references somewhat provisional. A large *Aphelops* comparable to *A. malacorhinus* is represented by a perfect skull from the upper beds; a small and primitive *Teleoceras* found in the lower Snake Creek is referred to *T. medicornutus*. A fine *Peraceras* skull of unrecorded level is provisionally placed in the later fauna. The majority of the teeth and jaw fragments from the lower Snake Creek belong to a large *Aphelops* provisionally identified with *A. crassus* of Leidy, and the small, typical *A. megalodus* is not recognized except in the Sheep Creek quarries (Hor. A).

Palæomeryx is characteristic of the Lower Snake Creek, *Dyseomeryx* and *Blastomeryx* are found in all levels, but the species appear to be distinct. The horizon of *Cranioceras* and *Neotragoceras* is not definitely recorded, but the former is from the Miocene and the latter from the Pliocene, so far as one can judge from the preservation of the specimens. *Megalonys* is definitely from the Pliocene.

¹Setting aside those of *Parahippus* and *Hypohippus*.

²It is difficult to distinguish milk teeth of *Hipparion*, *Pliohippus* and *Protohippus* from each other by any characters that will apply to all the species referred to each genus.

The occurrence of these scarce forms, like that of the primitive-toothed *Talpa* in the lower and the progressive-toothed *Scalops* in the upper level, and of various other rarities in the collection, conforms well enough with expectation, but can hardly be cited as evidence for the distinctness of the two.

CORRELATION OF THE FAUNAS

Merychippus primus ZONE

This zone is on record as the lower part of the Sheep Creek beds, containing *Merychippus* "*isonesus*" *primus* (now regarded as a distinct species). A channel-bed facies of the formation is well exposed in a small "draw" which is designated as "Stonehouse draw" and was worked by the Museum party in 1922-3. The collection obtained is as large as has been secured from the *paniensis* zone, and clearly earlier, although not so sharply distinct as are the *M. paniensis* and *H. affine* zones. The correlation seems to be with the earliest phases of the *Merychippus* zone, older than the Mascall, possibly equivalent to the rather scanty and fragmentary fauna described by Merriam from Phillips Ranch in the Mojave region.

Merychippus paniensis ZONE

It will be observed that all the species which Leidy recorded from Bijou Hills are found in the Pawnee Creek and Snake Creek, except for *Hippodon speciosus*, which was based upon an indeterminate type. The metatypes of *H. (Merychippus) speciosus* are upper teeth which may quite well be the same as *M. paniensis* of the Pawnee Creek and Snake Creek, but it is not certain whether or not they are true topotypes. *Merycodon necatus* of Bijou Hills is represented in the Pawnee Creek by *M. osborni* (? = *M. necatus*), in the Snake Creek by *M. necatus* and a doubtful subspecies, *M. n. sabulonis*; *Leptarctus primus*, based on an upper p⁴ from Bijou Hills, is represented by skulls and jaws from both Pawnee Creek and Snake Creek described in this paper.

The correlation with Pawnee Creek is based on the following species:

PAWNEE CREEK	LOWER SNAKE CREEK
<i>Tomarctus brevirostris</i>	<i>Tomarctus brevirostris</i>
" <i>temerarius</i>	" <i>temerarius</i>
<i>Euoplocyon</i> sp.	<i>Euoplocyon prædator</i>
<i>Amphicyon sinapius</i>	<i>Amphicyon sinapius</i>
<i>Leptarctus primus</i>	<i>Leptarctus primus</i>
<i>Plionictis ogygia</i>	<i>Plionictis glaræ</i>
" <i>parviloba</i>	" ? <i>parviloba</i>

PAWNEE CREEK
Pseudælorus intrepidus var.
Teleoceras medicornutus
Hypohippus osborni
Merychippus paniensis
 " *sejunctus*
 " *proparvulus*
 " *eohipparion*
Parahippus sp. div.
Protolabis angustidens
Merycodus osborni
Dromomeryx borealis
 " ? sp.
Blastomeryx gemmifer

LOWER SNAKE CREEK
Pseudælorus intrepidus var.
Teleoceras medicornutus
Hypohippus osborni
Merychippus paniensis
 " *sejunctus*
 " *proparvulus*
 " *eohipparion*
Parahippus integer
Protolabis angustidens
Merycodus necatus
Dromomeryx borealis
 " *whitfordi*
Blastomeryx gemmifer

This is a remarkably close correspondence for two formations of different physical type situated about a hundred miles apart. It amounts to a practical identity of fauna, making allowances for merely nominal species and for the accidents of preservation among rare or little-known forms, excepting as follows:

(1.) The camels correspond only in part. Nothing corresponding to the gigantic *Alticamelus giraffinus* has been found at Snake Creek.

(2.) The oreodonts (*Agriochoeridæ*) appear to be different generically, *Metoreodon* and *Pronomotherium* taking the place of *Merychys* and *Merychochærus*.

(3.) No proboscideans have been recorded from the lower levels of Snake Creek. They are very rare in the Pawnee Creek beds, so this may not have much significance.

These distinctions, such as they are, cannot be interpreted as indicating any difference in age. The absence of *A. giraffinus* from the Snake Creek would point one way, while the scarcity of the smaller and more primitive camels would point the other way; *Metoreodon* of the Snake Creek might be regarded as a descendant of *Merychys* of Pawnee Creek. *Pronomotherium* of the Snake Creek is certainly not derived from *Merychochærus* of Pawnee Creek, nor is it on the whole any more specialized. It appears to be derived from some species of Lower Miocene *Ticholeptus*. The differences between the two faunæ are probably only facies, due to some environmental difference, geographic range, or the selective action of different conditions of sedimentation.

Hipparion affine ZONE

The principal upper Snake Creek fauna is clearly distinct and of Pliocene age, comparable with that of the Republican River beds. There are some forms in it suggesting a later stage, but they are rare and im-

perfectly known, and their evidence is not weighty. The correspondence, however, is by no means so close as that between Pawnee Creek and lower Snake Creek. There are few species in common. *Teleoceras fossiger*, so abundant in Republican River, is not positively recorded from the Snake Creek. The Equidæ correspond fairly well as to genera, but not as to species. *Ælurodon* is the characteristic canid in both faunas.

Pliohippus leidymanus ZONE

This doubtfully distinct zone has not been well differentiated and is still only tentatively separated, as it was in Osborn's Equidæ memoir. A few specimens, mostly *Pliohippus*, have been found in the eolian dune-sands that appear to be the final member of the Mio-Pliocene sequence at the Snake Creek fossil quarries. Among them are the type skeleton of *P. leidymanus*, a skull of the same species, a number of *Pliohippus* teeth, and, if the writer's memory does not play him false, two jaws, one of *Protohippus*, the other of *Hipparion*, found in 1908. Also several rhinoceros jaws and bones of very large size but mostly indeterminate, a skull of *Megatylopus gigas*, and perhaps some other specimens, are probably from this horizon. Fossils are so scarce in it, however, that its distinctness has not been verified.

INSECTIVORA

TALPIDÆ

Scalops cf. *aquaticus*

A humerus, A. M. N. H. No. 17577, *Hipparion affine* zone, complete except that part of the head is broken off, agrees with the average of half a dozen specimens of the existing *S. aquaticus*.

It is altogether probable that this Lower Pliocene species would prove distinct from the modern form if one had a skull or even a good lower jaw for comparison. The humerus, however, is completely "modernized," quite distinct from "*Talpa*" *platybrachys* Douglass of the Flint Creek Miocene of Montana¹ (which may possibly be *Talpa* but probably is not).

Scalops sp. occurs in the Lower Pleistocene (typical "Loup Fork") of Nebraska.² It is not distinguishable from *S. aquaticus* in the lower jaw, the only part at hand for comparison.

¹Douglass, Earl. 1904. 'New Vertebrates from the Montana Tertiary.' Ann. Carn. Mus., II, p. 171, Fig. 13.

²Matthew, W. D. 1918. 'Contributions to the Snake Creek Fauna. With Notes upon the Pleistocene of Western Nebraska. American Museum Expedition of 1916.' Bull. Amer. Mus. Nat. Hist., XXXVIII, p. 228.

Talpa incerta, new species

TYPE.—A. M. N. H. No. 18891, a lower jaw with the last molar and alveolus of m_2 .

HORIZON AND LOCALITY.—*Merychippus paniensis* zone; Quarry B of 1921.

CHARACTERS.—Posterior portion of the jaw, so far as preserved, agrees with *Talpa*. The form and position of the coronoid appear to have been the same, although the major part of the process is broken off. The dental foramen agrees in size and position and in the form and curvature of the parts adjoining it. The angle is broken off. The depth and thickness of the jaw beneath the molars corresponds with *Talpa*. The size and general form of the last molar accords, so far as one may judge from the rather heavily worn tooth, except for the talonid, which is broader and lacks the deep external notch between trigonid and heel that is found in *Talpa* and various related genera. The alveoli of m_2 indicate a tooth of about the same size as in *Talpa*; the jaw is broken off in front of this point.

The reference of this jaw to *Talpa* is provisional. It certainly is not a shrew, as it has nothing of the deep coronoid pocket characteristic of the shrews. The position of the mental foramen and relations of adjacent parts are like the moles and unlike any bats that I have examined, nor does the molar agree as nearly with any of the latter as it does with *Talpa*. Nevertheless, it is likely that a better knowledge of the species would distinguish it generically from *Talpa*; but it is not advisable to base a new genus on the notch in the heel of m_3 . *Scalops* and *Scapanus* have much higher-crowned molars; in *Proscapanus* and *Proscalops* they are also higher.

Comparison with "*Talpa*" *platybrachys* Douglass is impossible as that species is known only from a humerus.

RODENTIA

Rodents are not especially common in the Snake Creek quarries, but a considerable variety of diverse types is represented, chiefly by fragmentary specimens. *Mylagaulus* and *Dipoides* are the most abundant. The following is the list:

Sciurus represents the family Sciuridæ.

Dipoides

and

Amblycastor, different sections of the Castoridæ

Poamys

Muridæ

Thomomys

Geomyidæ

Peridiomys

Heteromyidæ

Mylagaulus

Mylagaulidæ

Lepus (*Hypolagus*)

Leporidæ

It is to be observed that in spite of the relative scarcity of material the diversity of type represented—seven families—is greater than the

six families of the John Day, the five families of the White River, the three of the Uinta, two of the Bridger, one of the Wasatch. The progressive increase in diversity is not due to absolute or relative abundance of specimens in the collections compared, for rodents are quite as common, absolutely and relatively, in the Wasatch or Bridger as in the later Tertiary formations compared. It is not due to more diverse environment or wider geographic range, for the comparison is made between faunas each from a limited area and representing a single facies. It is explicable only by a progressive diversity of type in the order itself. The Wasatch rodents are all of one family and not of half a dozen or more presumably because there was only one family of rodents in the Lower Eocene. If this were true only of North America, we might suppose it possible that these diverse types existed elsewhere but had not yet reached this continent. But the same conditions prevailed in Europe at the corresponding epochs; so far as the record shows, they prevailed elsewhere; and from these data one must conclude that these diverse types had not come into existence in the Lower Eocene, that the number and divergence of the rodents increased progressively from a single family in the Wasatch to a dozen in the Pleistocene, and that most of the existing families were already established by the end of the Oligocene, but that their divergent specialization increased down to the present day. As this conclusion will be disputed by some zoölogists and palæontologists, I think it well to point out the facts upon which it is based. I cannot see any other reasonable conclusion from these facts.

MYLAGAULIDÆ

A skull, a considerable number of palates, upper and lower jaws, many isolated teeth (mostly the enlarged premolar) and a few doubtfully referred limb bones represent this family in the lower Snake Creek. In the upper beds it is rare, known only from a few teeth.

The genera of Mylagaulidæ remain in considerable doubt and confusion. *Mylagaulus* was described by Cope from an upper p^4 of a small species, *M. sesquipedalis*, which is the type, and a lower p_4 of a somewhat larger species, *M. monodon*, both from the Republican River beds. Gidley's *Epigaulus hatcheri* is based on a skull and skeleton from the same formation, and is probably identical with *M. monodon*.¹ In the Pawnee Creek beds of Colorado two skulls have been found, a smaller, hornless form described as *M. lævis*, and a larger, horned skull described

¹There are some slight differences in pattern of p_4 , probably due to age.

as *Ceratogaulus rhinocerus*. It may well be doubted whether *M. sesquipedalis* is really congeneric with the hornless *M. lævis*; and it is open to question whether *Epigaulus* should be regarded as a distinct genus from *Ceratogaulus*, although undoubtedly a distinct species. The age variations in the tooth patterns are very wide, but the age variations in the skull are not known. It is possible that the horned and hornless



Fig. 2. *Mylagaulus lævis* skull; palatal view, showing p^4 at an early stage of wear, m^{1-2} lost and alveolus of m^1 nearly closed, m^3 beginning to wear. No. 17576, Snake Creek beds, *M. paniensis* zone. Three halves natural size.

types are sex variations. It is quite true that no other rodents display such wide sexual differences, but no other rodents bear horns, and horned mammals frequently do display similar sex variations. A fourth genus has been described, *Mesogaulus*, based upon a lower jaw from the Deep River, which, if correctly described, differs from any other specimens that I have seen in a heavy external investment of cement. Pend-

ing evidence to clear up these problems, I retain the described genera provisionally.

The molars in the Mylagaulidæ are progressively deciduous, m_1 dropping out shortly after the large premolar breaks through the jaw, m_2 and m_3 at later stages of wear. The alveolus of m_1 is early reduced and disappears as the premolar pushes its way upward; the alveolus of m_2 is similarly eliminated and that of m_3 is reduced and finally disappears



Fig. 3. *Mylagaulus lævis*; superior view of skull, same as Fig. 2.

before the premolar is wholly worn down. Mr. Douglass has interpreted the m_1 as dp_4 and the p_4 as p_3 , but this interpretation is certainly erroneous.

In the Lower Snake Creek beds two species are represented, apparently *M. lævis* and *C. rhinocerus*. In the upper beds there are also two species more doubtfully identified as *M. sesquipedalis* and *E. monodon*. It may be that these represent two parallel phyla, one hornless, the other horned. More primitive species, *M. vetus* and *M. novellus*, are found in the Sheep Creek beds.

***Mylagaulus lævis* Matthew**

Mylagaulus monodon Matthew, 1901, Mem. A. M. N. H., I, p. 377, Figs. 3, 4, 5, 6.

Mylagaulus lævis Matthew, 1902, Bull. Amer. Mus. Nat. Hist., XVI, p. 298.

The type is an incomplete skull and pelvis from the Pawnee Creek beds of Colorado.

The best Snake Creek specimens referred to it are No. 17256, a skull, finely preserved, but lacking the nasal bones, part of the basi-cranial region and the right zygomatic arch, and No. 18896, a palate of a very old individual, with p^4 worn down almost to the roots, m^2 worn down to the posterior root, and the open alveolus of m^3 .

The skull is rather young, with the sutures distinct. P^4 has but recently come into use and has not yet attained full size; it has not yet wholly obliterated the alveoli of m^1 , of which the posterior outlines are still recognizable. M^2 is represented only by a circular alveolus on each side. M^3 is still retained on both sides, a small short tooth which has evidently but just begun to wear, but is apparently destined to fall out early. It is subconical, the point of the cone removed by wear to a surface of pattern as in the figure, the diameters, especially the antero-posterior one, increasing toward the base of the crown. The palate between the tooth rows is of constant width and extends a little behind m^3 ; the outer alveolar borders converge rapidly. The skull resembles that of *Haplodontia* more than that of any other rodent, but is more exaggerated in its peculiar proportions. The width across the zygomata is slightly greater than the total length of the skull; and the width of the occipital crest is only slightly less than the entire length of the skull. This excessive occipital width is attained through an extreme lateral expansion of the occipital and lambdoidal crests into a wide plate. On the posterior face of this plate the exoccipitals occupy the inner third, and external to them lies a very wide mastoid plate, continuous with the tympanic bulla and with the petrosal, but separated by a suture from the overlapping exoccipital plate. On its external and superior border this mastoid plate overlaps in turn and is suturally separated from a wide flange forming the lateral extension of the occipital crest. I cannot be certain of the composition of this flange. The post-tympanic portion of the squamosal is plastered on to the front of it, separated by a suture along the margin; the rest of the flange may be a lateral expansion of the supraoccipital, as the more mediad portion certainly is; but there appears to be an obliterated suture marking the lateral limit of the supraoccipital, and the portion of the flange beyond it may be the parietal, which among the hystricomorph rodents certainly does send out a postero-lateral projection that is intercalated between the post-

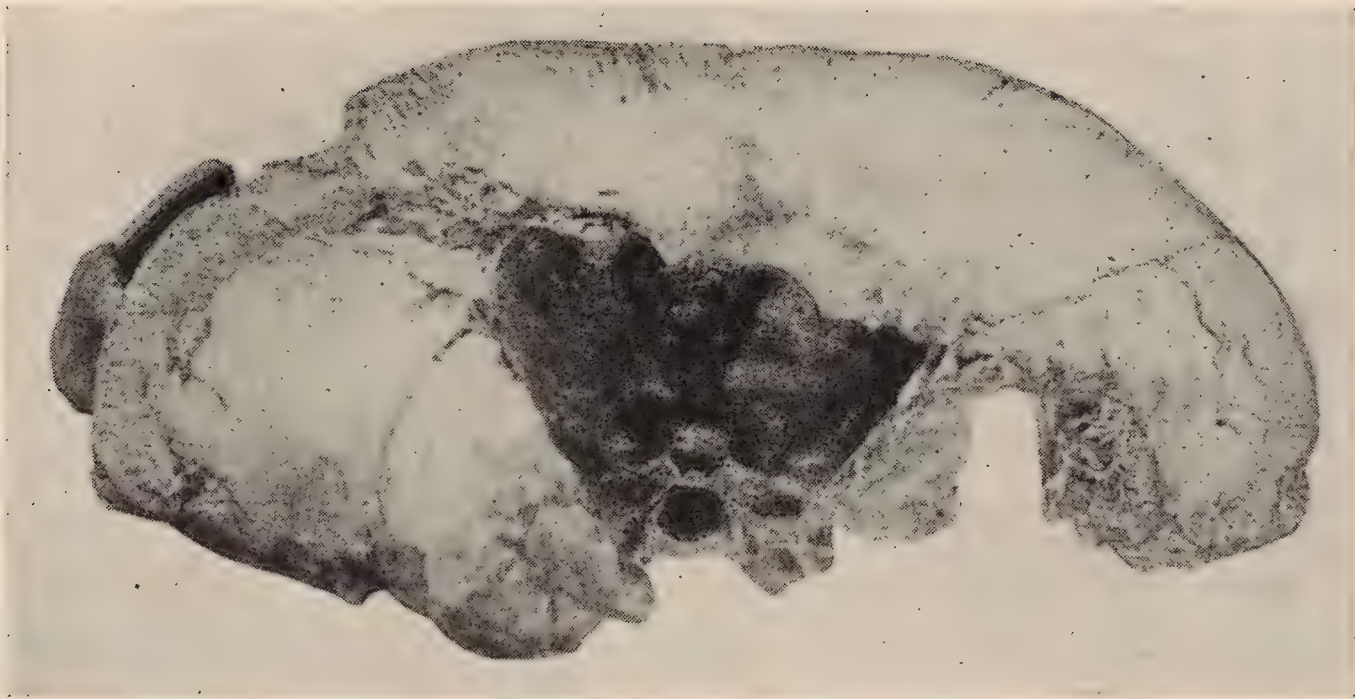


Fig. 4. *Mylagaulus lævis*; posterior, anterior and left side views of skull shown in Fig. 2.

tympanic portion of the squamosal and the lateral wing of the supraoccipital, and projects a little further laterally along the transverse occipital crest than does the supraoccipital. The condition in *Mylogaulus* may be a specialization based upon such relations as may be seen among hystricomorph rodents.

The tympanic bulla is moderately expanded, hollow, and has a long bony meatus; its proportions throughout are much like those of *Haplo-*



Fig. 5. *Mylogaulus vetus*; skull, palatal view; young individual showing dp^{3-4} and m^1 , with the posterior teeth not yet emerged. No. 18903, Sheep Creek beds, *M. primus* zone. Three halves natural size.

dontia. The alisphenoid is plastered against the anterior face of the bulla, but does not extend far over it. The sutures of the sphenoidal group and of the squamosal are mostly obliterated. The sutures separating the parietals from each other and from the frontals are mostly obliterated but apparently the parietals extend far enough forward to share in the postorbital process, extending out on its postero-inferior surface almost to the tip of the process. The postorbital crests on the parietals are quite near together, converging backward from the postorbital processes

to the anterior end of a small raised triangle of bone that is probably the interparietal, then diverging sharply and curving outward to join the occipital crest. The supposed interparietal is separated from the post-orbital crests by a sharp deep furrow, and by a smaller one from the median portion of the occipital crest.

The postorbital process is quite prominent, flat and blunt-ended. A somewhat similar projection at the anterior margin of the frontal projects laterally, making the antero-superior border of the orbit; and between these two equally prominent processes lies the orbital notch. The lacrymal ? the maxilla, the premaxilla and the nasal bones abut successively against the anterior border of the frontal, almost in a transverse row, except that the premaxilla extends somewhat farther back than the others. The width of the premaxilla at this suture is about twice that of the nasal, and about equal to the conjoined maxilla-lacrymal sutural line.

The zygomatic arch is very thick and heavy. Its width is comparable with that in some fossorial rodents; the postorbital process of the jugal is strong; the masseteric scar is limited to the inferior face of the arch and does not quite reach its inner base; it is separated from the anterior surface by a sharp angulation. The infraorbital foramen is small, circular, surrounded by a larger depressed area, characteristically like the *Sciuravus-Ischyromyoid* group from which *Mylagaulus*, *Aplodontia* and a few other rodents have retained this primitive condition.¹

DENTITION.—A lower jaw obtained in 1921 gives the long desired evidence of the milk dentition in this group. It is clear that the *Mylagaulus paniensis*, *Mesogaulus ballensis* and other peculiar types of dentition that were considered by Matthew as possibly the milk teeth of *Mylagaulus*, are not so but are permanent dentitions of different species, very likely pertaining to different genera. The milk premolar is a short-crowned *Allomys*-like tooth, totally unlike its permanent successor. Were it not for the presence of that successor, preformed beneath the milk

¹Miller and Gidley, in their recent revision of the super-generic groups of rodents, have distributed this primitive group into a number of more specialized stocks which, at first glance, appear in their classification to be rather widely diverse in structure. A re-examination shows, however, that there is no such wide diversity of structure among the Eocene rodents as their classification would appear to indicate, as (1) the Eocene and Oligocene genera assigned to the specialized groups lack the specialized structures distinctive of these groups and have to be cited as exceptions in the diagnoses; (2) the broad distinction made, into fundamentally tricuspid and tetracuspid types, appears to the present writer wholly imaginary in some instances, clearly erroneous in a few, and a gratuitous and unnecessary distinction in all cases. In instance of this may be cited the wide separation made between *Mylagaulidæ* and *Allomyidæ*, the only cited justification being that the primary pattern of the teeth is tetragonal in the one, trigonal in the other, family. In point of fact, the surface pattern of the unworn teeth is almost identical in *Allomys* and *Mylagaulus*.

For these reasons and others not specified here, it seems inadvisable to accept the very elaborate and complex scheme of revision proposed by Miller and Gidley and the old arrangement is retained provisionally, although undoubtedly capable of much improvement.

tooth, and of the three molars behind, unmistakably those of *Mylogaulus*, although only m_1 is worn, the lower jaw in question would not have been referred to this family.



Fig. 6. *Mylogaulus vetus*; top view of skull No. 18903.

***Mylogaulus vetus*, new species**

TYPE.—No. 18905, a lower jaw with p_4 , m_2 and alveolus of m_3 .

PARATYPES.—18903, 18904, skulls with milk dentition and permanent teeth beneath; 18906, 18907, lower jaws.

CHARACTERS.—The species from the Sheep Creek A beds is intermediate in size between *M. lævis* and *M. paniensis* of the Snake Creek A beds, but the molars are relatively larger and more persistent, the premolars less elongate-oval.

The most interesting feature in the rodent material collected in 1922 was the proof that *Mylogaulodon* Sinclair is the milk dentition of *Myla-*

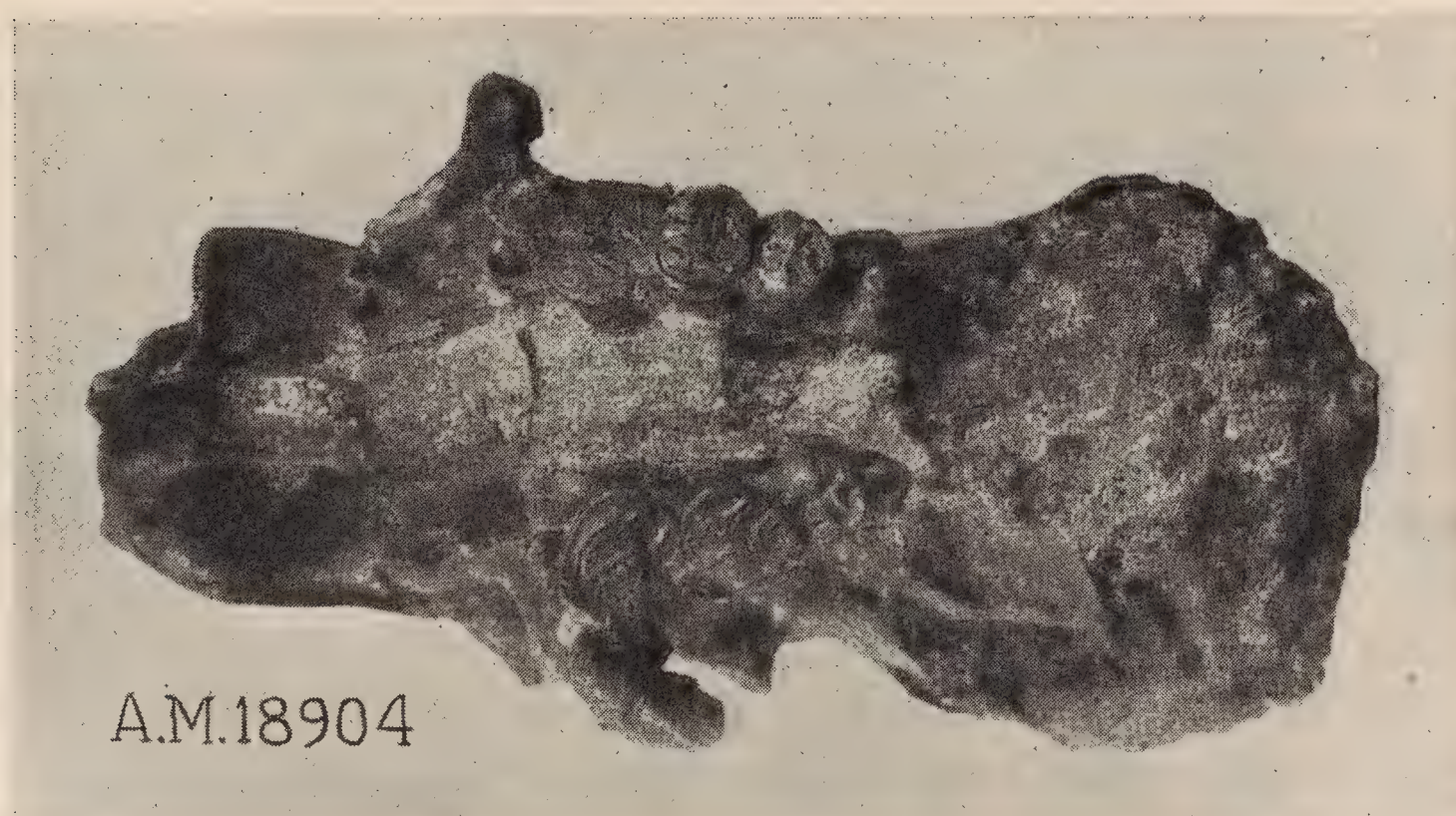


Fig. 7. *Mylagaulus vetus*; part of skull No. 18904, palatal view with milk dentition, twice natural size. Dp^{3-4} and m^{1-2} are preserved. From the same quarry as No. 18903.



A.M.18902



Fig. 8. *Mylagaulus vetus*; lower jaw; young individual with dp_4-m_3 , the permanent premolar preformed in the jaw. No. 18902, Sheep Creek beds, *M. primus* zone, inner and outer views of jaw, three halves natural size; and crown view of teeth, three times natural size.

gaulus. Two skulls of this species show the milk dentition, dp^4 in place and well worn, m^1 moderately worn, m^2 and p^3 emerging but not yet in wear, m^3 and p^4 preformed in the jaw.

The characteristic resemblance in form of the milk premolar to *Meniscomys*, together with the marked approach in pattern of the unworn p^4 and molars of *Mylagaulus* to *Meniscomys* and the Aplodontiidae generally, affords strong support to the view advanced by E. S. Riggs in 1899 that the Mylagaulidae are a specialized offshoot from the *Meniscomys-Allomys* group of the John Day. The tenor of the evidence appears, on the other hand, to be quite adverse to the wide separation between Allomyidae and Mylagaulidae indicated by Miller and Gidley. Nevertheless, as the published revision of these authors is based upon a more thorough study of the most complete series of existing and extinct rodents that has been brought together, their conclusions are highly authoritative, although unfortunately they have not yet been able to publish the evidence upon which they rest.

***Mylagaulus novellus*, new species**

TYPE.—No. 18911, lower jaw, dp_4 , p_4-m_2 and alveolus of m_3 r.

HORIZON AND LOCALITY.—Middle Miocene, Lower Sheep Creek beds (Hor. A), Stonehouse draw, Exped. 1922.

CHARACTERS.—Size the least in the genus, premolar small in proportion, conical rather than cylindrical in middle portion. The anteroposterior diameter of the premolar about 4.8 mm. as against 8.5 in *M. paniensis*, 8.5-9 in *M. vetus* and *laevis*, 12 in *M. monodon*.

The type and only specimen is of minute size and immature, the premolar preformed in the jaw, while the milk molar was in place as found but has been removed to clear up the surface of p_4 . The crown of this tooth shows the usual structure of four oblique cross-crests, the second interrupted towards the inner half of its course, bending sharply forward to join the first, but restored at the inner margin as an isolated pillar, all four crests connected by sub-median commissures. This pattern is progressively changed so that in the lower half of the crown it has become a series of narrow transverse lakes.

Sciurus* cf. *aberti

A well-preserved lower jaw, A. M. N. H. No. 17578, from Quarry No. 1, Upper Snake Creek beds is not distinguishable from the jaw of the modern *S. aberti*, but is almost equally like any other of the large western black squirrels. It is a little too large, too deep-jawed and heavy-toothed for the common eastern gray squirrel.

Peridiomys¹ rusticus, new genus and species

TYPE.—No. 18894, lower jaw with incisor, p_4 - m_2 and alveolus of m_3 , from *M. paniensis* zone, Quarry B., 1921.

CHARACTERS.—Molars very short-crowned, with simple cross-crests without commissures, buttresses or irregularities of line, or any noticeable forward pitch. Size and proportions of jaw much as in *Heteromys*, construction of molar teeth nearer to *Perognathus*.

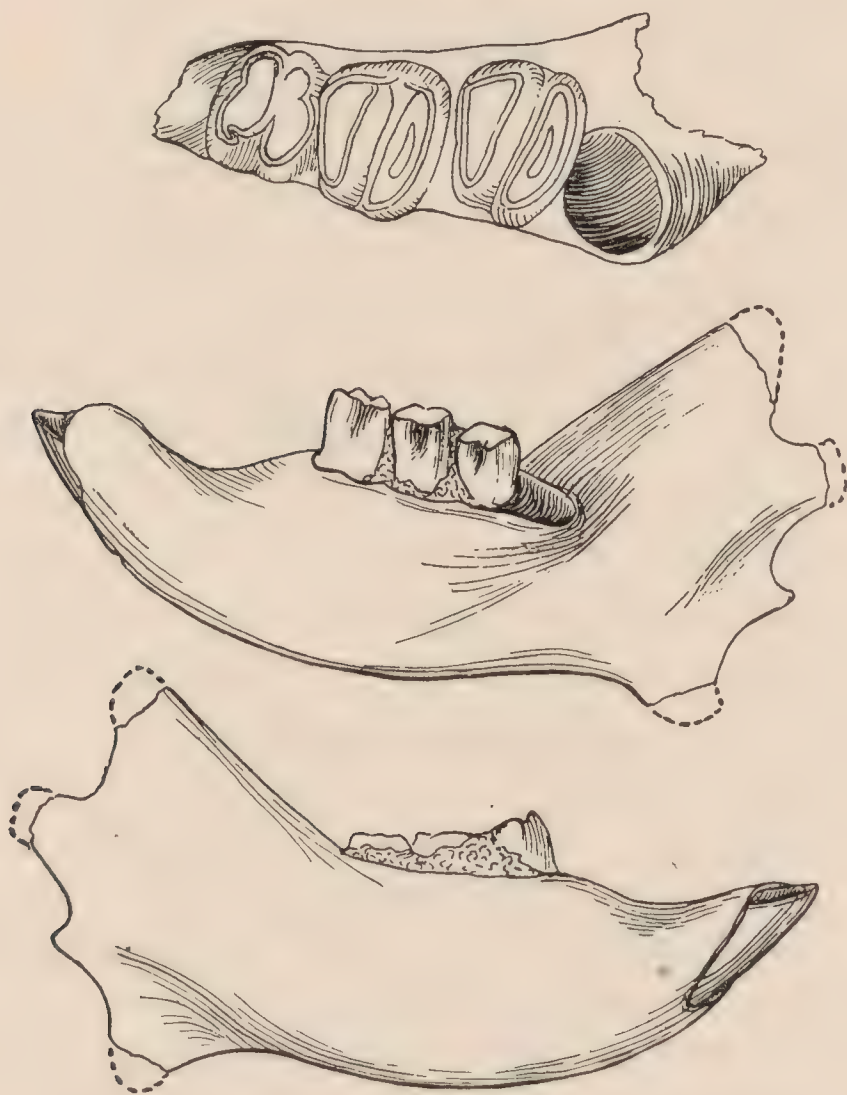


Fig. 9. *Peridiomys rusticus*; type, lower jaw with incisor and p_4 - m_2 preserved. No. 18894, Snake Creek beds, *M. paniensis* zone. Inner and outer views of jaw, enlarged two-and-a-half times; and crown view of teeth, enlarged to five diameters.

This pocket-mouse appears to be most nearly related to *Perognathus*, but it can hardly be included within the modern genus. The cross-crests of the molars are very simple and smooth, as in *Heteromys*, but much shorter-crowned and lacking the commissures of that genus. The crests of *Perognathus* are somewhat higher, irregular, and pitch forward in a marked degree; the species are all of smaller size with more slender jaws.

¹Derivation: *πηριδιον*, dim. fr. *πηρα*, a pocket; *μυς*, mouse.

Poamys¹ rivicola, new genus and species

TYPE.—No. 18892, a lower jaw with m_2 and alveoli of m_1 and m_3 ; from *M. paniensis* zone, Quarry B, 1921.

CHARACTERS.—Teeth brachyodont, crown nearly as short as in *Peromyscus*, but the pattern of the tooth fundamentally that of the meadow-mice, with two sharp angulate external pillars and rounded internal pillars, connected by transverse crests and with a commissure between the crests toward the inner end.

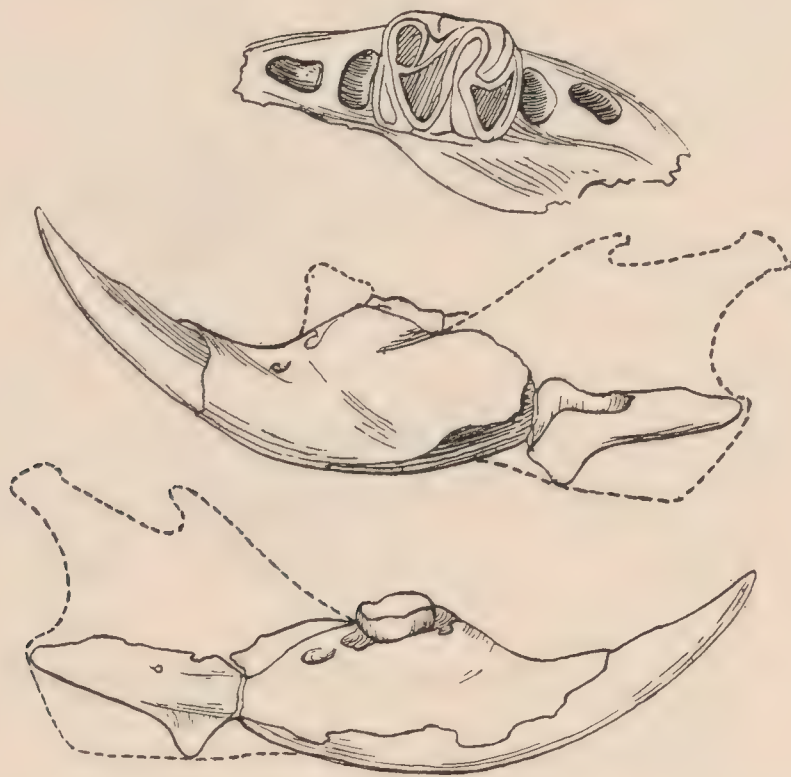


Fig. 10. *Poamys rivicola*; type, lower jaw with incisor and m_2 preserved, No. 18892, Snake Creek beds, *M. paniensis* zone. Inner and outer views of jaw enlarged two-and-a-half times; and crown view of teeth, enlarged to five diameters.

I am unable to find any modern genus in which this species can be included. So far as the evidence goes, it appears to be a short-crowned type, structurally ancestral to the Microtinæ. Whether it was even approximately ancestral in a genetic sense remains to be proven. It is of interest to note, however, that hypsodont Microtinæ do not appear in the geological record until late in the Pliocene.

Lepus (Hypolagus) vetus Kellogg

This species is distinguished by a less development of the anterior column of p_3 than in the modern *campestris* and *virginianus*. It is intermediate between the *L. ennisianus* of the John Day, *macrocephalus* and *primigenius* of the Rosebud, and the modern typical *Lepus*. Matthew in

¹Derivation: $\pi\alpha\alpha$, grass, by epon, a meadow; $\mu\upsilon\varsigma$, mouse.

1907 distinguished these three species as a primitive group intermediate between *Palæolagus* and *Lepus* in dentition, pointing out that *L. macrocephalus* at least has the skeleton proportions of *L. campester*, not of such supposedly primitive survivals as *Sylvilagus*, *Caprolagus*, etc.

Doctor Dice in 1917 erected *L. ennisianus* into a separate genus, *Archæolagus*. He does not allude to the two Rosebud species but they would presumably fall into the same genus, which is separable by a number of generic characters of the skull from any of the existing rabbits. He also distinguishes *L. vetus* generically under the name of *Hypolagus*. This species is based upon a lower jaw from the Thousand Creek Pliocene of Nevada, and two lower jaws and an upper tooth from the Virgin Valley Miocene were referred to it by Miss Kellogg. I refer to it provisionally No. 18909, a lower jaw from the *paniensis* zone of the Snake Creek beds with p_2 - m_1 preserved. No. 18910, two incomplete jaws from the *primus* zone (Hor. A) of the Sheep Creek beds, may be referred with still more doubt to *L. vetus*; neither of these has p_2 preserved. It is open to doubt, as Doctor Dice observes, whether the referred specimens belong to the same species as the type, and it does not appear to me that the intermediate character of p_2 between *L. ennisianus* and modern *Lepus* is in itself a sufficient basis for full generic distinction. A better knowledge of the later Miocene and Pliocene rabbits may prove that one or both are entitled to rank as generically distinct from the modern forms on one side, and the Upper Oligocene and Lower Miocene species of *Archæolagus* on the other, or that they are closely allied to the earlier or to the later group; but until we have adequate evidence as to their real position it seems better to rank *Hypolagus* as a provisional subgenus, and avoid giving it equal status with the well-distinguished genus *Archæolagus*.

CARNIVORA

Fossil remains of carnivora are not unusually abundant in the Snake Creek collections, but they represent a surprisingly large variety of genera and species, chiefly of Canidæ and Mustelidæ. The best specimens are from the lower beds, in which have been found skulls of *Tomarctus*, *Pliocyon*, *Amphicyon* and *Leptarctus*, which aid greatly in clearing up the affinities of these genera and the phylogeny of the two families.

The *Leptarctus* skull is not only of great interest on its own account, but it has enabled me to identify a skull and jaws found in 1901 in the Pawnee Creek beds, which, on account of the damaged teeth, I could

never identify before and had refrained from describing because of its very singular skull proportions, widely different from the normal carnivore type. It is now positively identifiable with the Snake Creek skull, and through that with Leidy's type of *L. primus*. The canid skulls have provided the evidence necessary to support a somewhat different view of the phylogeny from that generally accepted.

CANIDÆ

TOMARCTUS Cope, 1873

Synonym: *Tephrocyon* Merriam, 1906, in part at least.

Type: *T. brevirostris* of the Pawnee Creek beds, based upon a lower jaw fragment with m_1 , A. M. N. H. No. 8302.

The genotype is a young individual with the carnassial unworn and only partly emerged from the jaw. The specimen is broken off behind the carnassial and broken away obliquely in front of it, so that part of the premolar root-sockets can be distinguished, although nothing of the alveolar border. Cope interpreted these sockets as indicating a reduced number of premolars; but of this there is no real evidence. A similarly immature *Tephrocyon* or *Canis* jaw, broken off in the same way, would show the same incomplete and unreliable indications of the premolar roots. The genus really rests upon the characters of the carnassial, which are very clearly shown in the unworn type. They are as follows:

(1.) Heel bicuspid, as in the typical dogs (*Tephrocyon*, *Ælurodon*, and the modern wolves, foxes, jackals, etc.

(2.) Trigonid relatively large, compressed, with small metaconid set partly back of the protoconid, as in *Tephrocyon* and some modern Canidæ.

Tomarctus is certainly excluded by the characters of the carnassial heel from the amphicyonine, cuonine, or other aberrant groups of Canidæ, as well as from the genera of the Oligocene and Lower Miocene, all of which retain the primitive viverroid construction of m_1 . It is allied to *Ælurodon*, but distinguished by the somewhat more compressed and elongate carnassial. It agrees exactly with *Tephrocyon hippophagus*, is of the same geological age and part of an equivalent, closely related and largely identical fauna, not widely separated geographically from the Snake Creek quarries, which have yielded species unquestionably of the Mascall genus. There are no characters in the carnassial to distinguish it from *Canis* and related modern genera, but if *Tephrocyon* = *Tomarctus*, there are good generic distinctions from any of the existing dogs.

I have long suspected this identity and have hesitated to adopt *Tomarctus* mainly because of the lack of topotypes, and the possibility that it might represent an allied but distinct genus. It has become increasingly evident, however, that the fauna of the Lower Snake Creek zone is very close to the Pawnee Creek fauna, and there is no longer any



Fig. 11. *Tomarctus brevirostris*; lower jaw, No. 18244, natural size; external, crown and internal views, natural size. Snake Creek beds, *M. paniensis* zone.

reasonable probability that the two genera are distinct. It is quite probable that the species are identical, but adequate proof of this is lacking, and they may yet prove to be distinct.

Whether or not generic distinctions may be found between *Tomarctus* and *Tephrocyon rurestris* of the Mascall may be left open for the present,



Fig. 12. *Tomarctus brevirostris*; skull, No. 18242, Snake Creek beds, *M. paniensis* zone. Side view, three-fifths natural size.

as it calls for a careful comparison of the typical skull of *T. rurestris* with the skulls herein described, which may be regarded as neotypes and approximate topotypes of *Tomarctus*.

AFFINITIES OF *Tomarctus*.—Merriam has expressed the opinion that *Tephrocyon* is in a broad way ancestral both to *Ælurodon* and to *Canis*. The affinities of the species here considered as typical of *Tomarctus* would bear out this view, if allowance be made for the difference in geologic



Fig. 13. *Tomarctus brevirostris*; top view of skull shown in Fig. 12.

age, which has brought about much more progressive modification in the modern *Canis* than in the early Pliocene *Ælurodon*. The skull shows a very considerable difference from *Canis* but mostly, if not altogether, in primitive characters. The much smaller brain-case and strong sagittal and occipital crests are doubtless primitive; *Ælurodon* in this respect comes nearer because it represents a Lower Pliocene stage of evolution. The special features that distinguish the modern genera of Canidæ, considered in the narrower scope, are not yet differentiated in the species of *Tephrocyon*, so far as any really conclusive evidence goes. Without doubt one might single out individual characters distinctive of the modern genera and find them foreshadowed in the Miocene species. But we do not find an association of characters in each species that foreshadows in all points the association of characters distinctive of each modern generic group; and that, in my opinion, is necessary to constitute proof; otherwise, we may be dealing with parallelism.

***Tomarctus brevirostris* Cope, 1873**

Type: a lower jaw fragment, A. M. N. H. No. 8302, from the Upper Miocene Pawnee Creek beds of northeastern Colorado.

Tephrocyon hippophagus Matthew and Cook, 1909, is a synonym. Its type, A. M. N. H. No. 13836, is a lower jaw from the Snake Creek beds.

To this species are referred three fine skulls, various upper and lower jaws and a large series of teeth and other fragmentary specimens, all from the lower zone of the Snake Creek.

The skull is about the size of that of a jackal. It is comparatively broad and short-muzzled.

DESCRIPTION OF SKULL.—Based upon three nearly complete skulls, Nos. 18242, 18243, and 18244, collected by the Museum expedition of 1921. These three skulls, while differing slightly in almost every detail of construction, are clearly conspecific, and the lower jaw associated with one of them agrees very well with the type jaw. All are somewhat larger individuals than the type of *T. hippophagus*, but probably not specifically distinct.

The skull is of about the size of the larger "species" of coyote, but is much more like a timber-wolf in proportions. The muzzle is shorter and broader posteriorly than in the timber-wolf, the frontals somewhat wider relatively, the sagittal crest somewhat longer and about equally high, the occipital crest decidedly different in form, being expanded laterally at the top into a square-topped occiput, quite unlike the tri-

angular-topped occiput of wolf and coyote. Some South American Canidæ (*C. aquilus*, etc.) show this character. The position of the orbits is considerably further back than in wolf or coyote or any other modern species which I have compared. The front of the orbit is above the



Fig. 14. *Tomarctus brevirostris*; skull, No. 18243, Snake Creek beds, *M. paniensis* zone. Top and side views, three-fifths natural size.

posterior half of p^4 , the postorbital processes above m^2 . In the modern species the front of the orbit is above or behind the line between p^4 and m^1 ; the postorbital processes are quite back of the molar teeth. The position of the infraorbital foramen is less changed; in *Tomarctus* above a line between p^3 and p^4 , in *Canis* above the posterior part of p^3 . The

superior branch of the premaxilla is much longer and stronger than in modern *Canis*, and is met by a corresponding anterior extension of the frontal, wholly excluding the nasals from contact with the maxillaries. I have not found this character in any modern Canidæ but it is nearly approximated in some South American species, *C. urostictus*, *C. aquilus*. It is a characteristic feature in the skull of *Ælurodon*.

The zygomatic arches are as deep proportionately as in the timber-wolf; the postorbital processes are nearly as prominent as in this species, much more so than in the smaller modern Canidæ.

In the basicranial region the bulla has completely the character of the modern *Canis*. It is more inflated, especially posteriorly, than in *C.*



Fig. 15. *Tomarctus brevirostris*; No. 18243, palatal view of skull, three-fifths natural size.

occidentalis, slightly more than in *C. latrans*, about as in the South American *C. aquilus*. The postglenoid processes are relatively farther apart, the bony meatus more extended outwardly, the postglenoid foramen more prominently defined by the lip of the meatus. The paroccipital process is sutured to the back of the bulla, nearly to its tip, as in modern *Canis*. The alisphenoid canal is somewhat longer than in *Canis* (except some South American skulls among those that I have examined). The position and relations of the remaining basicranial foramina agree closely with the wolves and coyotes.

The palate is somewhat broader and shorter than in *C. occidentalis*, much broader than in the coyote and most other species of *Canis*; and



Fig. 16. *Tomarctus brevirostris*; skull, top and side views three-fifths natural size. No. 18244, same individual as the lower jaw shown in Fig. 11.

the premolars are fully as massive as in the wolf. The carnassial is somewhat smaller relatively and the molars are relatively larger, especially m^2 . The carnassial shows that slight obliquity of shear which is still seen in several of the modern South American species of *Canis*, but wholly lost in the species of the northern world. The relative proportions of carnassial and molars is nearly that of the coyote, but the premolars are very different from the slender, compressed, spaced premolars of *C. latrans*, and the triangular-based carnassial is more like *C. aquilus*, etc. The parastyle on the carnassial is a distinct cusp, a feature

not found in any modern species, characteristic of *Ælurodon*, in which the cusp is decidedly larger. It shows a wide variation in the different individuals referred to this species; in some it is quite rudimentary, stronger in others. Development of this cusp appears to be partly associated with reduction in relative size of the carnassial and enlargement of the molars; and it is possible that in the rather wide range of variation that has been included under *T. brevidens* there are in fact two species, one the true *hippophagus*, the other closer to the typical *T. brevidens* of the Pawnee Creek.

MEASUREMENTS IN MILLIMETERS, AND PERCENTAGES OF BASAL LENGTH

No. 18242, Quarry B.

Basal length, premaxillæ to condyles (length from par-occipital process to condyle estimated)	156	100
Dentition, total length, including alveoli to m ²	86	55.1
Width of skull across zygomata	111	71.2
Width of palate across m ¹	60	38.5
Width of basicranium across post-glenoid foramina	53.5	34.3
Width of basicranium across mastoid process	63	40.4
Width between orbits	33	21.2
Length of muzzle (anterior border orbit to pmx, slant measurement)	62.5	40
Width of cranium, postorbital process to occipital crest	96	61.6
Postorbital constriction	25.5	16.4
Molar teeth, m ¹⁻²	19.5	12.5
Carnassial, length	18.5	11.8
Premolars, length	23.5	15.7
Width across canine alveoli	35.3	22.6
Width across incisive alveoli	25	16
M ² , diameters, antero-posterior × transverse	7.3 × 12	
M ¹	13.1 × 18	
P ⁴	19 × 8.9	
P ³	11.2 × 5.4	
P ²	9.5 × 4.3	

PERCENTAGE COMPARISONS OF *Tomarctus* WITH MODERN CANIDÆ

All figures except the first line are percentages of basal length of skull	<i>Tomarctus</i> <i>brev.</i> No. 18242	<i>Canis</i> <i>occident.</i> (Wolf) No.—	<i>Canis</i> <i>microdon</i> (Coyote) No. 22776	<i>Canis</i> <i>aquilus</i> "Dog-fox" S. Amer. No. 14637
Skull, actual basal length	156	217	178	130
Skull, percentage length as above	100	100	100	100
Dentition, length, i ¹ -m ²	55.1	53.8	55.9	55.4
Skull width, across zygomata	71.2	57.9	51.4	53.0
Palate width, across m ¹	38.5	34.7	28.5	30.1
Basicranial width between post-glenoid foramina	34.3	27.9	26.4	30.5
Basicranial width across mastoid processes	40.4	36.3	32.7	35.5
Width between orbits	21.2	20.9	16.5	19.7
Muzzle, preorbital length ¹	40	47.5	47	43.3
Cranium, postorbital length ²	61.6	52.1	50	47.5
Postorbital constriction, width across	16.4	17.5	20	25.4
Molars, length m ¹⁻²	12.5	9.7	9.7	13.0
Carnassial, length	11.8	11.1	10.2	9.7
Premolars, length p ¹⁻³	15.7	15.9	19.6	16.8
Muzzle, width across canine alveoli	22.6	21.5	16.9	16.5
Incisors, width across	16	14.5	13.1	11.5

***Tomarctus confertus* Matthew**

I refer to this species a finely preserved skull No. 18253, from the lower zone of the Snake Creek beds. It may be compared in detail with the skull of *T. hippophagus* and *Tephrocyon rurestris*. The construction is, as one might expect, more delicate throughout; the cranium has no sagittal crest and the occipital crest is rudimentary; the arches are not preserved but were evidently quite slender. The most distinctive feature is the notable shortness of both muzzle and cranium. To some extent this was indicated by the short and thick lower jaw, but it is more marked in the skull.

The short, deep muzzle is in marked contrast with the longer slender, delicate muzzle that is indicated by the correspondingly long and slender lower jaw of *Leptocyon*. The latter exaggerates one of the distinctive characters of the foxes and coyotes; but there is nothing else to connect it with these modern species.

¹Slant length, i¹ to anterior border of orbit.

²Postorbital process to occipital crest.



Fig. 17. *Tomarctus confertus*; skull, natural size, top, side and palatal views. No. 18253, Snake Creek beds, *M. paniensis* zone.

Tomarctus temerarius Leidy

The status of this species is not clear. Leidy based it in 1858 upon two specimens, a fragment of an upper jaw with m^1 and part of p^4 and a fragment of lower jaw with m_1 , mentioning them in that order. In 1869 he figured the second specimen but not the first. The second specimen has been referred to as the type by several subsequent authors, but not expressly so designated to the exclusion of the first. In the U. S. National Museum catalogue of types it is listed as though both fragments were supposed to belong to the same individual. This is hardly possible; they differ too much in size. The upper jaw fragment belongs to an animal only slightly smaller than the small variant of *T. brevirostris*. The lower jaw fragment belongs to an animal one-fifth smaller, and only a little larger than *T. confertus*. Peterson and Merriam have referred fragments of lower jaws to *T. temerarius*, stating that they agreed closely in size with the type lower jaw figured by Leidy. But in fact they do not; they are about one-fifth larger; they conform rather closely with the unfigured upper jaw fragment but it is decidedly doubtful whether they are in either case co-specific with the lower jaw fragment figured by Leidy, and with various specimens which I have referred to *T. temerarius* at different times, relying upon their accord with that figured lower jaw.

If Osborn's usage be adopted, of considering as type (lectotype) the first-mentioned specimen of the original description, then the unfigured upper jaw fragment will be the type of *T. temerarius*, and the specimens referred by Peterson and Merriam agree with it. I cannot find any sanction save Osborn's personal preference for this usage and many authors would consider that the figuring of the lower jaw fragment by Leidy and its implicit selection as type by Matthew, Peterson and Merriam constitute a selection of type which must stand, in accordance with the rules.

Tomarctus optatus, new species

TYPE.—No. 18916, a pair of lower jaws with complete dentition.

HORIZON AND LOCALITY.—Sheep Creek A, Stonehouse draw.

CHARACTERS.—Intermediate in size between *T. brevirostris* (*Tephrocyon hippophagus*) and *T. temerarius*.

This species is represented by a considerable number of topotypes which agree closely in size. It does not differ much in construction or proportions from the type of *T. temerarius* on one hand and of *T. brevirostris* on the other, and agrees closely in size with the cotype upper jaw

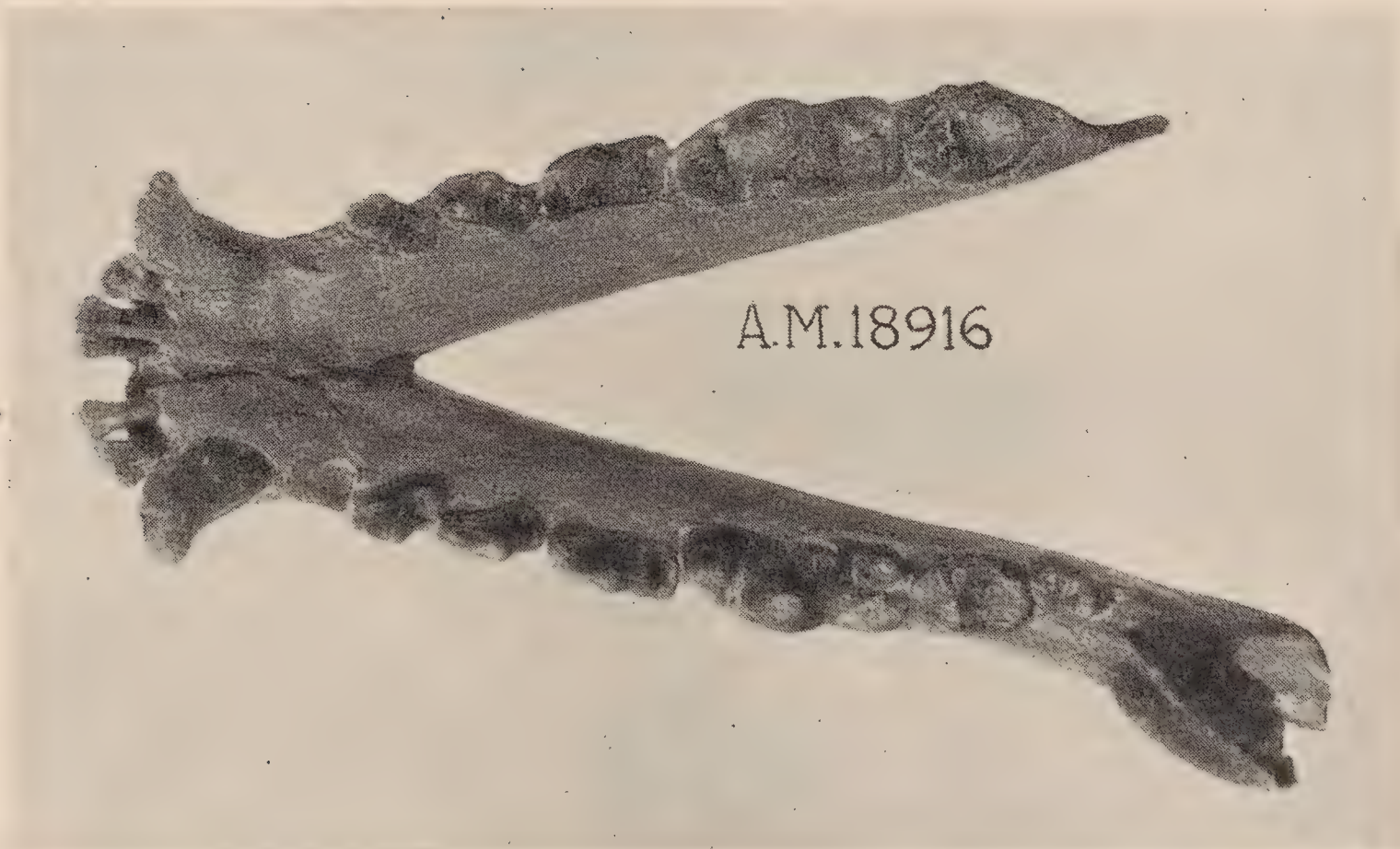


Fig. 18. *Tomarctus optatus*; lower jaw, natural size, external and superior views. Type specimen, No. 18916. Sheep Creek beds, *M. primus* zone.



Fig. 19. *Tomarctus optatus*; upper jaw fragment, natural size. No. 14176, Sheep Creek beds, collection of 1908.

of *T. temerarius* and with specimens referred to that species by Peterson and by Merriam. They differ from the species here identified as *temerarius* in larger size, longer jaw and narrower teeth, and from *brevirostris* in the smaller size and somewhat slenderer proportions. They are closely allied, however, and it is very probable that *T. optatus* is a primitive mutant of *T. brevirostris*. Until the evidence is adequate to prove this relationship it appears better to hold the names distinct. A skull found in 1923 but not yet carefully studied probably represents this species.

***Ælurodon haydenianus validus* Matthew and Cook**

To this subspecies is referred an upper jaw with p^4 - m^1 , left side, from the Upper Snake Creek beds, Quarry No. 1.

CHARACTERS.—Inner cusp of p^4 absent, but inner root strong. Crown of p^4 elongate, of uniform width in front and behind. The surface is so worn that the three cusps are indicated only by the color of the dentine—yellowish-white where more deeply worn under the cusps, bluish-gray elsewhere. M^1 almost as large as p^4 , its transverse width somewhat less than the anteroposterior diameter of p^4 but its anteroposterior diameter greater than the transverse width of p^4 . Inner half of m^1 nearly as wide as outer half, giving this tooth also a subquadrate outline. The tooth is nearly symmetrical on a transverse axis, the inner half lacking the backward twist characteristic of most Canidæ. Hypocone somewhat larger than protocone, heavy but somewhat obsolete anterointernal cingulum; protocone-metaconule crest heavy, anterior wing of protocone crescent obscure; outer half of tooth much worn.

P^3 appears to be a rather small tooth and m^2 is also somewhat reduced, so far as one can judge from the imperfect alveoli.

This upper jaw is probably the same as the lower jaw from Snake Creek described in 1909 as a mutation of *Æ. haydenianus*. It is broadly similar to various upper dentitions that have been referred to that genus. It is, however, the most specialized of the genus.

So far as one can judge from Merriam's figure and description, *Ælurodon aphobus*¹ of the Ricardo Pliocene is closely related to this species and may also be a subspecies of *Æ. haydenianus*, which, curiously, is the only one of the described species with which the author does not compare it.

***Hyænognathus direptor*, new species**

TYPE.—No. 18919, left ramus of mandible, complete except for incisor and anterior premolar teeth, from Upper Snake Creek beds, *Pliohippus* draw.

CHARACTERS.—Size of *Ælurodon sævus*, premolars reduced in number and size, heel of m_1 and whole of m_2 shortened, m_3 reduced compared with that genus. Denti-

¹Merriam, J. C., 1919, Univ. Calif. Publ., Bull. Dept. Geol., XI, p. 535.



Fig. 20. *Hyænognathus direptor*; lower jaw, natural size, external view and crown view of teeth. Type specimen, No. 18919, Upper Snake Creek beds.

tion $\overline{3.1.3.3}$. Incisors probably rather large, to judge from size of alveoli; the second and third have much longer roots than the first. Canine rather small, about as in *Æ. sævus*. First premolar absent, no postcanine diastema; p_2 with a single round, rather shallow root. P_3 also single-rooted, with a distinct external groove; both teeth appear to have been obliquely set in the jaw. P_4 very like that of *Hyænognathus pachyodon* and *Ælurodon sævus*, short and stout, the principal cusp stout and high, pitched backward and curved inward, crowded back against the posterior accessory cusp and heel so that its point lies directly above them at a certain stage of wear.

M_1 very like that of *Ælurodon*, the heel somewhat shorter but with the characteristic bicuspid construction of the typical dogs. M_2 decidedly shorter than in *Ælurodon* and subquadrate, the paraconid well developed but apparently without entoconid. M_3 small and circular in outline, cusps worn to a flat surface. Jaw much as in *Ælurodon* but shorter and more massive, with deeply excavated masseteric fossa, heavy angle, short symphysis. The symphysis is by no means so heavy as in *H. pachyodon*, nor is the jaw so massively proportioned, especially toward the symphyseal region. It is about two-thirds as large.

AFFINITIES.—The species appears to be intermediate between *Ælurodon sævus* and *Hyænognathus pachyodon* but agrees more nearly with *Hyænognathus* in the extent and character of premolar reduction and in the form and proportions and cusp construction of m_{2-3} , the carnassial construction being about the same in the two genera. It differs from *Aræocyon* Thorpe, which has some points of resemblance in the general proportions and in the premolar reduction, in the bicuspid heel of m_1 , as also in retention of p_2 and p_3 and somewhat different heel and accessory cusp upon p_4 . Doctor Thorpe makes as characteristic of his genus a long m_2 and absence of m_3 . Neither tooth is preserved in the type and to judge from his figure the ascending ramus back of the molars is split off too far down to allow of any certainty as to whether m_3 was present or not, while the direction of the split also would tend to make the posterior alveolus of m_2 appear much longer than the real length of the alveolus at its natural border. I do not think Doctor Thorpe's specimen warrants any conclusion on the length of m_2 or the absence of m_3 ; it might in these respects be like *Hyænognathus*. The difference in the premolars, while considerable, is of a kind notoriously variable with age or individuals in the modern wolves. On the other hand, the median crested heel of m_1 , if positively and unmistakably present, would exclude the genus from the Caninæ. It would fall into the Simocyoninæ, whether or not it be at all nearly related to *Simocyon*. If this be so, it clearly can have no bearing on the *Hyænognathus* phylum. *H. direptor* appears, on the whole, to be a fairly close intermediate, indicating the derivation of *H. pachyodus* from *Æ. sævus*.

Mr. Harold J. Cook has referred to *Porthocyon*, under the name of *P. pugnator*, a species from the Republican River horizon in Yuma

County, Col., based upon a palate and lower jaw which are also somewhat intermediate between *Ælurodon* and *Hyænognathus* but appear to me to be more properly referable to *Ælurodon*. The characters of m_{2-3} are not known but the premolars do not appear to be reduced as they are in *H. pachyodon* and *direptor*, and the upper teeth agree more nearly with *Æ. sævus* than with the *Porthocyon* skull, whether or not this genus is the same as *Hyænognathus*.

The geological occurrence is as follows:

Hyænognathus pachyodon Pleistocene or late Pliocene, Kern Co., Cal.

H. direptor. ? Lower Pliocene, *Pliohippus* zone, Snake Creek.

Ælurodon sævus secundus. Lower Pliocene, Snake Creek.

Æ. "sævus" (Cope skeleton). Lower Pliocene, Republican R., Neb.

Æ. ("Porthocyon") pugnator Cook. Lower Pliocene, Yuma Co., Neb.

Æ. sævus Leidy, type jaw. Lower Pliocene, Valentine beds, Fort Niobrara, Neb. Other specimens from the Little White River, S. D. and elsewhere agree closely with Leidy's type.

Euoplocyon prædator, new genus and species

TYPE.—No. 18261, a lower jaw from the Miocene, Snake Creek quarries of Nebraska.

GENERIC DIAGNOSIS.—Dentition $\overline{3.1.4.3}$. Anterior and posterior heel-cusps and posterior accessory cusp on all four premolars. Carnassial with trenchant heel and no metaconid; m_2 with crested trigonid and crested heel.

The genus is distinguished from *Cyon* and *Icticyon* by retention of m_3 as a small, oval, sub-crested tooth, and by the more complex construction of the anterior premolars. From *Lycaon*, by complete loss of metaconid, the more complex structure of p_1 , more complete creasting of the tubercular teeth. From *Enhydrocyon*, by retaining m_3 and p_1 , and more compressed premolars with accessory cusps. From *Temnocyon* by loss of metaconid, different character of premolars, etc. It belongs unquestionably to the same group of the Canidæ as the above genera, and is not closely related either to the typical Canidæ, which include *Ælurodon*, or to the *Amphicyon* group.

This, probably, is the genus which I have heretofore called "*?Cyon*," as in the very fragmentary or immature specimens previously available there was nothing definite to distinguish it from the modern genus.¹ It appears to be, in a broad sense, intermediate between *Temnocyon* and *Cyon*; *Enhydrocyon* would stand as a precocious, *Lycaon* as a persistently

¹Matthew, W. D., 1902, Bull. Amer. Mus. Nat. Hist., XVI, p. 285.

primitive relative, so far as their dentition is concerned. I am unable to determine its exact relations to certain Pleistocene South American species, "*Canis*" *moreni*, "*Palæocyon*," etc., of which there is no good figure and no competent description of the lower teeth. They are probably related.

UPPER DENTITION.—This is not known in the type species but a specimen recently described by Dr. Malcolm Thorpe¹ under the name of *Ælurodon taxoides magnus* belongs to *Euoplocyon*, although to a much larger species. The type consists of associated upper and lower jaws, part of a tibia, etc. The crested heels of the lower molars immediately exclude it from *Ælurodon* and associate it with the *Cyon* group of Canidæ; the prominence of the accessory cusps, preservation of m_3 , absence of metaconid on m_1 , accord with *Euoplocyon*.

The upper teeth, as shown in Dr. Thorpe's type, are, as would be expected, near to *Cyon* in character and proportions, but distinguished by the strong development of the accessory cusps on the premolars and a small parastyle on the carnassial. The protocone of the carnassial is absent; the protocone of m^1 is relatively small, as usual in the cyonine group, but appears to be bifid.

Canis texanus Troxell² is based upon a lower jaw, and upon upper teeth and skeleton fragments apparently of doubtful association, from the Rock Creek beds, Lower Pleistocene, of Texas. If correctly described and figured it certainly does not belong to the typical group of Canidæ, and may be referable to the cyonine phylum, but probably rather to *Palæocyon* or *Dinocynops* than to *Euoplocyon*.

AMPHICYON Lartet

Type: *Amphicyon major* (Blainville, 1841) from Middle Miocene of Sansan.

This genus has been used in a very loose way by European and American authors to include canid species which have but little in common with the type save the dental formula of m_3^3 . How much weight should be attributed to the retention of m^3 may be questioned. It is, at all events, certain that the American Oligocene species referred here by Cope³ belong in other genera; and it appears highly probable that the species from the European Oligocene⁴ would also be distinguished if more fully known.

¹Thorpe 1923, Amer. Journ. Sci., III, p. 440, Figs. 9-11.

²Troxell, 1915, Amer. Journ. Sci., XXXIX, p. 627.

³*Amphicyon vetus*, *hartshornianus*, White River, = *Daphæus*. *Amphicyon cuspigerus*, *entoptychi*, *transversus*, John Day, = *Paradaphænus*.

⁴*Amphicyon ambiguus*, Phosphorites; *rugosidens*, Bohnert; *Amphicyon lemanensis*, Saint-Gérand-le-Puy.

Wortman in 1901 described a well-preserved upper jaw from the "Loup Fork" under the name of *A. americanus*.¹ It is distinguished from *A. major* by smaller size and more triangular and transversely extended molars (compare *A. lemanensis*, etc. and *Paradaphænus*), but it shows the double-edged canine, marked reduction of the premolars and spacing of the anterior ones characteristic of *Amphicyon*.

Matthew in 1902 described a species from the Pawnee Creek beds of Colorado more closely allied to *A. major*, based upon lower jaw frag-



Fig. 21. *Amphicyon sinapius*; lower jaw, superior and external views, two-fifths natural size. No. 18258, Snake Creek beds, *M. paniensis* zone.

ments with which a partial skeleton was provisionally associated. A number of described American species were also referred to *Amphicyon* and a complete but poorly preserved skull and jaws, with which was part of a skeleton, were described as *Dinocyon gidleyi*. The latter had but two upper molars, but was referred with grave hesitation to *Dinocyon*, which has typically much more quadrate molars. A species nearly allied to *D. gidleyi* was described by Earl Douglass² from the Lower Pliocene of

¹Wortman, J. L., 1901, Amer. Journ. Sci., XI, p. 200, March, 1901.

²Douglass, Earl, 1904, Ann. Carn. Mus., II, No. 2, pp. 192-195. Although dated 1903, this paper does not appear to have been actually published until 1904.

Montana under the name of *D. ossifragus* from an upper jaw and part of the basicranial region. In 1908 Matthew and Cook described *A. amnicola* of the Snake Creek beds, from a lower jaw. In 1910 Peterson, in reviewing the affinities of *Daphænodon*, regarded the American *Amphicyons*, *Dinocyon* and *Borophagus*, as a group distinct from the true *Amphicyons* of Europe, but did not separate them generically. Matthew in 1918 took substantially the same position and distinguished the "American *Amphicyons*" under the name of *Pliocyon*, with a new species, *P. medius*, as type, based upon a fairly good skull from the Snake Creek.

We now have a fine skull of *A. amnicola* from the same lower horizon of the Snake Creek as *P. medius*, and on comparison with the type of *Amphicyon major* it is at once evident that *A. amnicola* is closely allied in the tooth characters, and that it differs considerably from *P. medius* in the elongation of the muzzle, compression and spacing of the premolars, etc., as well as in absence of m^3 . Wortman's *A. americana* is a smaller species, distinguished from *A. amnicola* and *A. major* by the more triangular and transversely expanded upper molars. *A. americana* in these particulars approaches *A. lemanensis*, while *A. amnicola* must be regarded as a close ally of *A. major*, and *Pliocyon* can be held to include only those species which have but two upper molars, in most of which the premolars appear to be much more crowded than in *Amphicyon*. It is evident, however, on comparison of the details of skull structure and dentition that *Pliocyon* and *Amphicyon* are very closely allied in spite of superficial differences. *Pliocyon* is more primitive in dentition than *Dinocyon* and may be ancestral to it. The view that the American *Amphicyonines* were an independent parallel stock from the European *Amphicyonines* does not accord with the osteological facts, however plausible it may seem from a geographical viewpoint, for *A. amnicola* and *sinapius* are much more closely allied to *A. major* than they are to *A. americana*, which has some points of especial resemblance to the *lemanensis-ambiguus* group of Europe.

Pliocyon and *Amphicyon* are distinct genera, both represented in the American Miocene, and structurally derivable from *Daphænodon* by divergent specialization.

Filhol has described the skull of *A. lemanensis* and discussed its affinities to *Canis*; but the more recent discoveries of the complete skulls and skeletons of *Daphænus* and *Daphænodon* on the one hand, of *Cynodesmus* and *Tomarctus* on the other, modify in some degree the conclusions to be drawn.

It is very evident that *Daphænus*, *Daphænodon*, *Amphicyon lemanensis*, *A. major*, form a series which, in spite of Filhol's statements, are not



Fig. 22. *Amphicyon sinapius*; skull, palatal view, two-fifths natural size. No. 18257, Snake Creek beds, *M. paniensis* zone.

closely related to *Canis* or in any way ancestral to it. A second series is formed apparently by *Daphænodon-Pliocyon-Dinocyon*, and *Hyænarctos* may be a further specialization of this phylum. The point to be emphasized is that this entire group has a number of distinctive features, fairly warranting subfamily separation, viz.:

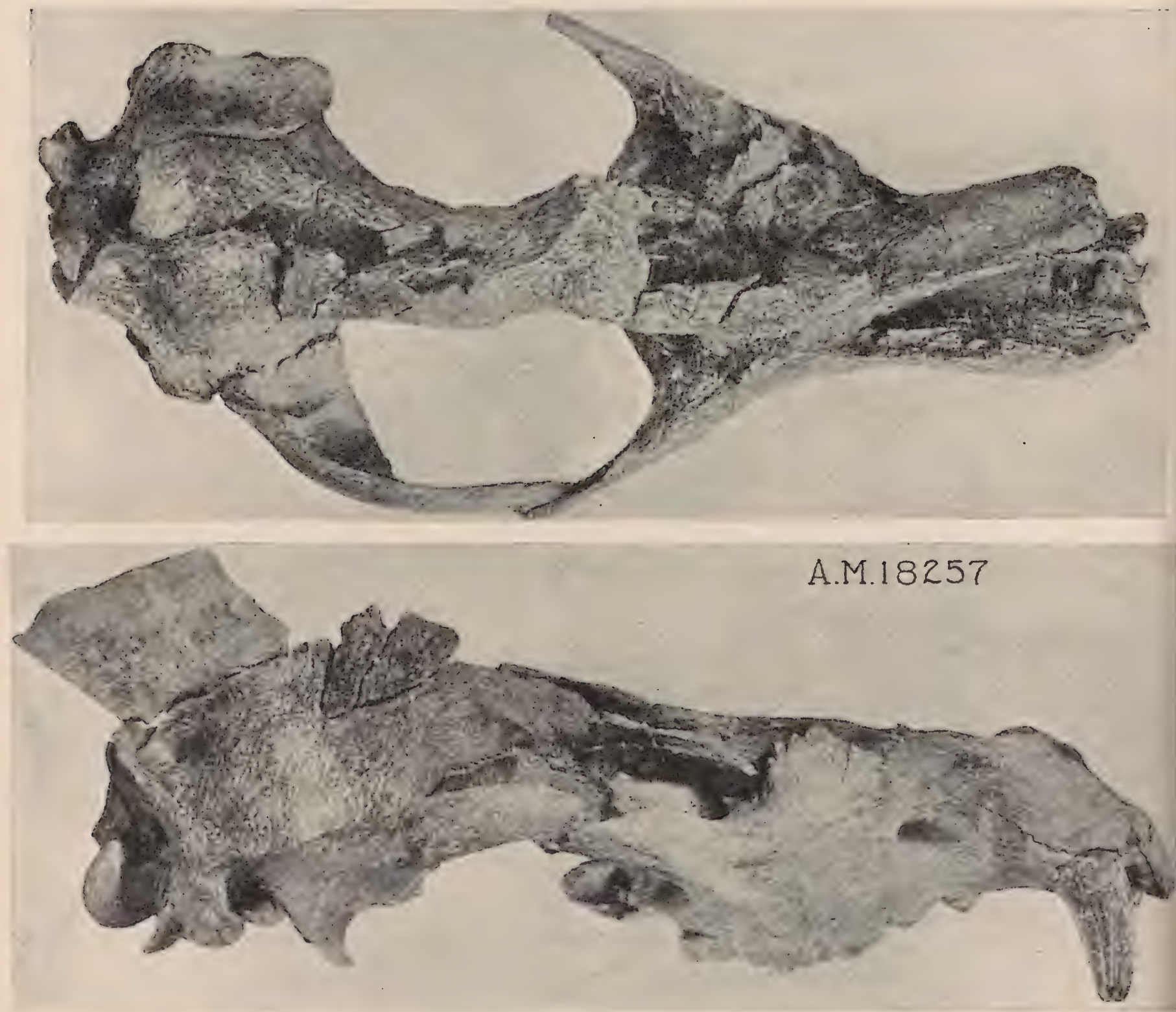


Fig. 23. *Amphicyon sinapius*; skull, top and side views, three-tenths natural size. No. 18257, same as Fig. 22.

(1.) Heel of m^1 crested, not bicuspid; heel of m_2 crested, not basined; premolars and carnassial reduced, molars enlarged, in varying degree.

(2.) Tympanic bulla small, never extending back of mastoid process¹; usually a long bony meatus.

¹Filhol states that the bulla in *A. lemanensis* extends backward to the posterior lacerate foramen; but this is based upon a specimen in the Lyons City Museum, which is perhaps of doubtful reference, as it was identified as *Cephalogale* by Lortet.

(3.) Tail very long and heavy; humerus broad distally with entepicondylar foramen, lower limb bones relatively short, astragalus short and wide, trochlea broad.

These characters in the successive geologic stages show a progressive diversity from the true dogs of the *Cynodictis*-*Cynodesmus*-*Tephrocyon*-*Canis* group, with which *Ælurodon* is closely allied.

A third group, primarily allied perhaps to the amphicyonines, but paralleling the Caninæ more closely in its specialization, is the icticyonine phylum, with *Daphænus*, *Temnocyon*, *Enhydrocyon*, *Philotrox*, *Euoplocyon*, *Icticyon*, *Cyon* and *Lycaon*.

Filhol's view that *Amphicyon* was ancestral to *Canis*, partly accepted by Boule, who regards it as ancestral to the wolves but derives the foxes from *Cynodictis*, is untenable on present data; both wolves and foxes are much more readily derived from species of *Tephrocyon*. On the other hand, the relationship between the amphicyonines and the Ursidæ is suggested by the numerous intermediate types from the middle and later Tertiary. I can find no serious grounds for deriving the bears from *Cephalogale*, which is closely related to *Cynodesmus* and is apparently a true Canine in the basicranial and other characters. Filhol's figure of *Cephalogale geoffroyi* is indeed a composite based upon several individuals, and in this instance as in his *Amphicyon lemanensis*, there may be doubt as to their association being correct. If, however, it be accepted, the large bulla, the fairly normal molar teeth and reduced premolar dentition compare with *Cynodesmus thomsoni*, to which it must be closely related; and this last species, known from a nearly complete skeleton, is certainly a true dog, though aberrant in respect to the premolar reduction.

What relationship there may be between *Ursavus brevirohinus* and *Cephalogale brevirostris* is another question, upon which it is not necessary to enter here. The object of the foregoing discussion is to show that the Ursidæ are in fact connected with the amphicyonine dogs by such a series of intermediate types as to demonstrate some degree of relationship; but until the skulls and skeletons of these intermediates are fully known and adequately described, their exact relations will remain uncertain.

***Amphicyon sinapius* Matthew**

Amphicyon sinapius Matthew, 1902, Bull. Amer. Mus. Nat. Hist., XVI, p. 288, Fig. 2. Type from Pawnee Creek, Colorado.

Amphicyon amnicola Matthew and Cook, 1909, idem, XXVI, pp. 368-370, Fig. 1. Type from Snake Creek, Nebraska.



Fig. 24. *Amphicyon ingens*; part of lower jaw, natural size. No. 18272, Snake Creek beds, *M. paniensis* zone.

The following specimens referred to this species give a fair idea of the characters of skull and skeleton:

No. 18257, complete skull. Snake Creek, 1921.

No. 18258, complete lower jaw. Snake Creek, 1921.

Nos. 18259, 18260, teeth. Snake Creek, 1921.

No. 13846, lower jaw (teeth worn). Snake Creek, 1908. Type *A. amnicola*.

No. 9358, jaw fragment m_{1-2} , Pawnee Creek, 1901. Type *A. sinapius*.

No. 9357, m_1 . Pawnee Creek, 1901.

No. 9356, vertebræ, ribs, humerus and ulna. Pawnee Creek, 1901.

No. 9355, parts of limb bones, astragalus, etc. Pawnee Creek, 1901.

There are in addition various separate bones, etc., that may be referable to this species. Its characters are as follows:

Size of *A. major* from Sansan (Middle Miocene of France). Upper teeth very like those of *A. major* throughout, but p^4 has a more distinct protocone (inner cusp), m^3 is more transversely extended. Much larger than *A. americanus* and the molars more quadrate; less transversely extended. I can find nothing in the teeth to separate *A. amnicola* from *A. sinapius* of the Middle Miocene of Colorado.

Amphicyon ingens, new species

TYPE.—No. 18272, anterior part lower jaw with damaged teeth or alveoli as far back as m_1 .

PARATYPE.—No. 18273, lower carnassial. Both from lower zone of Snake Creek beds.

CHARACTERS.—This is about the size of the large Pliocene species of *Agriotherium* (*Hyænarctos*); but the carnassial has the crested heel of the true Amphicyonines.

It is probable that to this species belong certain isolated carnivora skeleton bones from the Snake Creek; also possibly No. 9356, the paratype skeleton of *P. sinapius* from the Pawnee Creek beds.

Amphicyon frendens, new species

TYPE.—No. 18913, lower jaws with m_{1-2} emerged, c_1 and m_3 preformed, and upper jaw with p^4 - m^1 emerged, m^2 preformed, and m^3 partly calcified.

HORIZON AND LOCALITY.—Middle Miocene, Sheep Creek A, Stonehouse draw, Snake Creek fossil quarries.

CHARACTERS.—About ten per cent larger lineally than *A. sinapius*, the characters of the teeth approaching *Ischyrocyon* in various details; the carnassial blades sharper and higher, hypoconid crests higher, entoconid ledges reduced on m_1 and absent on m_2 . Alveoli of four premolars are present, less reduced than in *A. sinapius*, the anterior ones crowded in the jaw instead of being spaced out.

An upper molar, No. 18914, is of proportionate size to the type and differs from m^2 of the following species in the heavier metacone, more sym-

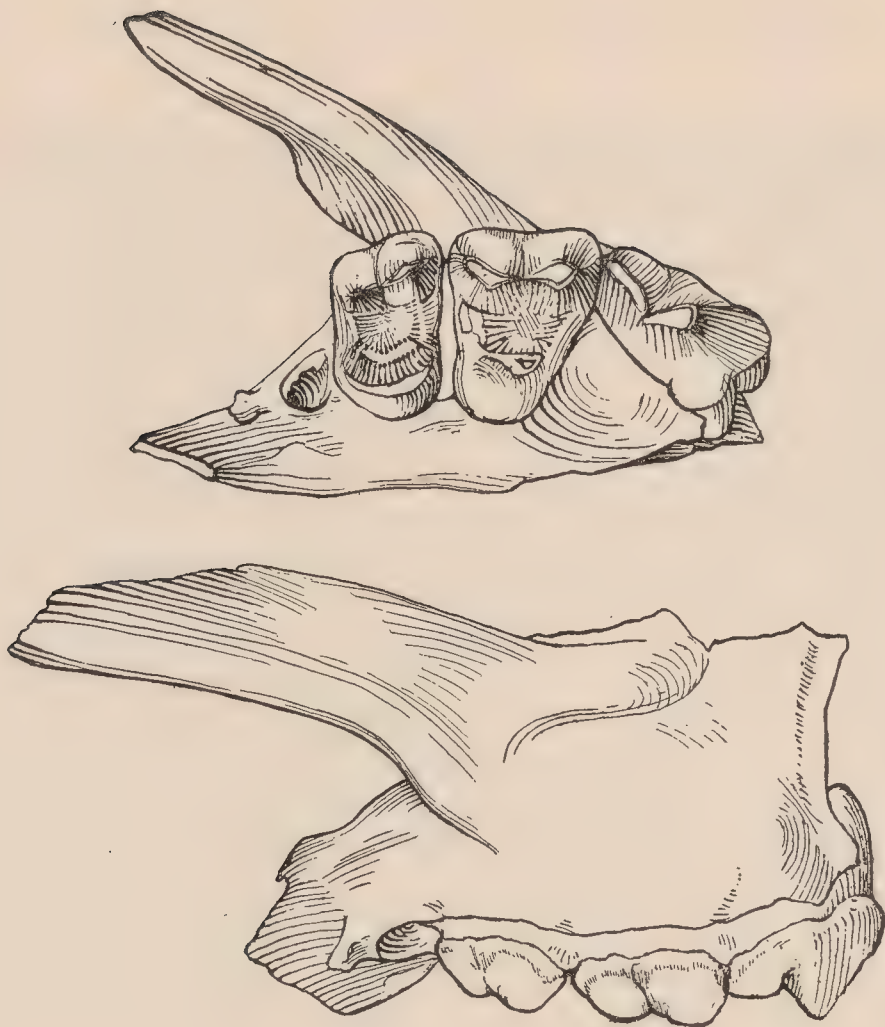


Fig. 25. *Amphicyon idoneus*; upper jaw, type specimen, one-half natural size. No. 18912, Sheep Creek beds, *M. primus* zone.

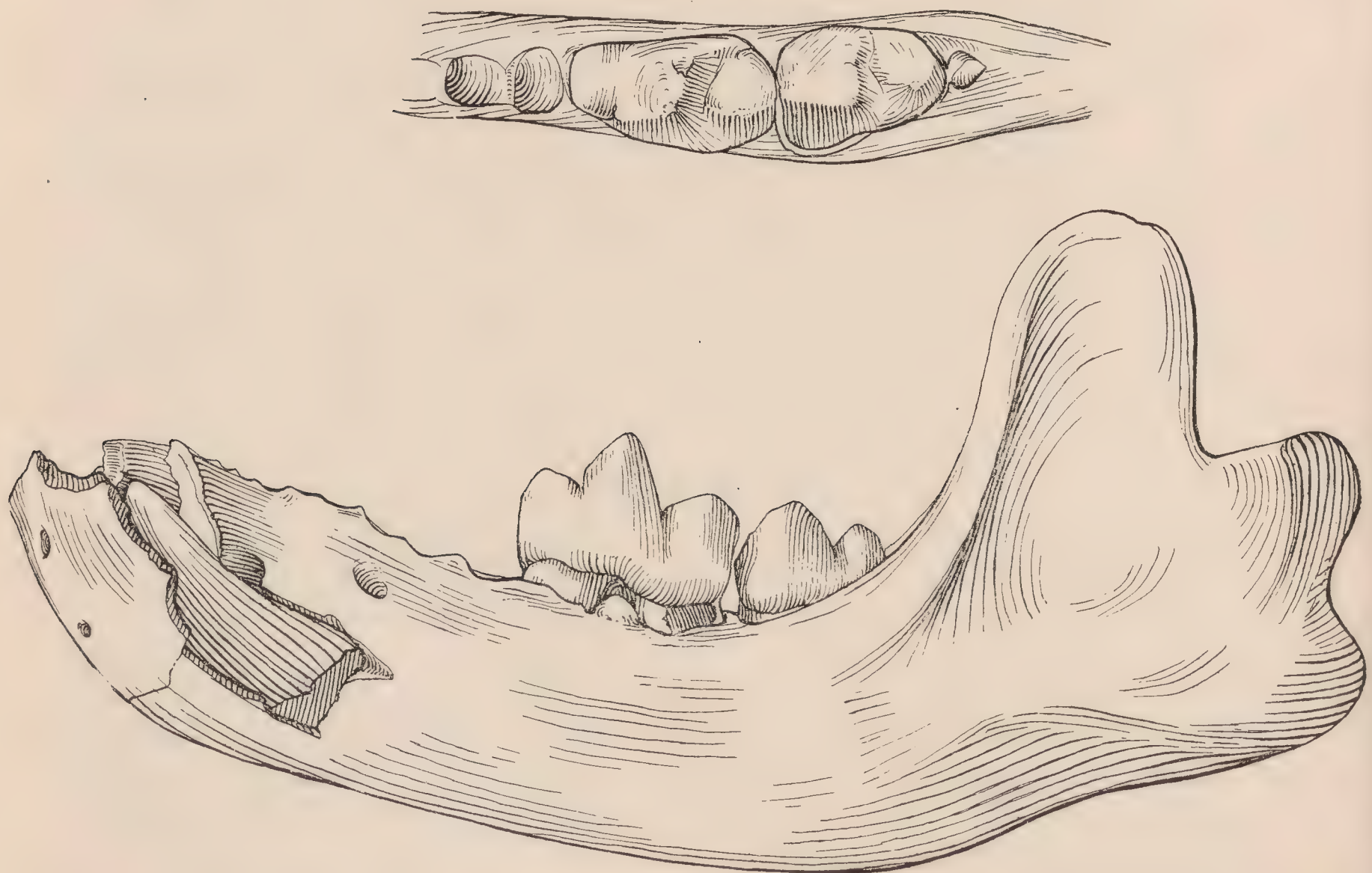


Fig. 26. *Amphicyon frendens*; lower jaw of type specimen, No. 18913, external view and crown view of teeth, one-half natural size.

metrical inner cingulum, the external half of the tooth relatively wider, with more massive cusps.

***Amphicyon idoneus*, new species**

TYPE.—No. 18912, upper jaw with p^4 - m^2 .

HORIZON AND LOCALITY.—Middle Miocene, Sheep Creek A.

CHARACTERS.—Size of *Pliocyon medius* and much resembling that species save for the retention of m^3 , indicated by a deep and fairly large alveolus. The metacone of m^2 is distinctly smaller and the internal cingulum broader and more extended anterointernally. The inner half of m^2 is nearly as wide as the outer half.

A fine skull of this species, found in 1923, is very like that of *A. sinapius* in proportions and tooth characters but of smaller size.

PLIOCYON Matthew

Not *Pliocyon* Thorpe 1921.¹

Type: *P. medius*, Lower Snake Creek beds.

The genotype is based upon a skull from the Sinclair Draw pocket. The species referred to the genus are the following:

Canis ursinus Cope, 1875, Santa Fé, New Mexico. Lower jaw, no teeth.

Ælurodon mæandrimus Hatcher. Republican R., Neb. Lower jaw, no teeth.

Dinocyon ossifragus Douglass, 1903. Madison, Montana. Parts of skull, etc.

Dinocyon gidleyi Matthew, 1903. Clarendon, Texas. Skull, jaws and part of skeleton.

Pliocyon medius Matthew, 1919. Skull.

To this genus or to *Amphicyon* is referred the following.

No. 2700, posterior half of skull and part of ulna, from the "Loup Fork" near Hay Springs fossil quarry, probably Valentine beds. This specimen was obtained in 1893 and identified by Dr. Wortman as a machærodont. It has always been under suspicion, as the basicranial structure was very different from any known machærodont or felid, but as the Felidæ of the American Upper Miocene and Pliocene were known only from jaws and the basicranial structure of the amphicyonine dogs was wholly unknown and they differed very widely in other points of skeleton structure from the typical dogs, it was not possible to identify this cranium with certainty. It differed widely from *Ursus* or *Arctotherium* but it was not provable and indeed is not now wholly certain that it could not be *Hyænarctos*.

¹Amer. Journ. Sci., I, pp. 470-480, Figs. 1-3.

Comparison with the skulls of *Pliocyon medius* and *Amphicyon amnicola* shows it to agree closely in all important structural characters. It is a large species, about the size of *P. mæandrinus*, to which it is provisionally referred.

The otic bulla, although only partly preserved in this specimen, was evidently similar to that of *P. medius* and *A. amnicola*, of small size, with rather long ossified meatus external to it. The bulla is almost wholly anterior to the mastoid process, the posterior chamber being absent. The mastoid process is much more massive, broader anteroposteriorly and more prominent than in *P. medius*; the paroccipital process is broken off. The posterior lacerate foramen lies at the bottom of a large deep pit, as in *P. medius*, but the condylar foramen opens within the posterointernal margin of that pit, while in *P. medius* it is slightly outside of it. The alisphenoid canal is long and straight and posteriorly opens into the usual oval pit at the back of which the foramen ovale opens. The scars for the recti capitis muscles are prominent rugosities with a sharply defined raised margin, between which and the bulla is a shallow channel apparently for the anterior carotid artery, which does not appear to pierce the bulla but to enter the anterior lacerate foramen in front of it. The occiput is high and narrow and the sagittal crest remarkably high.

As a whole the cranium of *Amphicyon* differs widely from any felid or machærodont type; fundamentally in the construction of the bulla and the retention of the alisphenoid canal. The high narrow occiput and large sagittal crest are primitive characters partly retained by the Canidæ; in the Mustelidæ and Ursidæ the occiput is relatively broad and low. The reduced bulla with long ossified meatus is a specialization usually associated with large size and found in Ursidæ and some Mustelidæ; but in the large Pliocene and later genera of these families the bulla is characteristically flattened as well as it is reduced. The development of the mastoid process and the internal position of the condylar foramen are size specializations apparently only of specific value, as they are less developed in *P. medius*. In all the basicranial features there is a marked resemblance between *Daphænodon*, *Amphicyon* and *Pliocyon*, carrying further the lines of specialization that separate those genera from *Daphænus*. The bulla is of identical type and relations but the meatus much longer; the mastoid process much more robust, the recti capitis scars more prominent, the paroccipital process more massive, the merger of f. l. p. and c. f. carried further.

Skeleton Characters of Amphicyonines

I have been unable to compare the cranium with *Hyænarctes* (*Agriotherium*) and *Indarctos*. I suspect that they would show closer affinities than do *Arctotherium* or *Ursus*; and the degree of affinity would have a most important bearing upon their relationship to the Amphicyonines and the entire problem of the ancestry of the Ursidæ. I have heretofore indorsed the opinion very generally held by palæontologists that this family may be more intimately related to the amphicyonine dogs and less so to the Mustelidæ than the comparative anatomy and osteology of the modern and Pleistocene Ursids would seem to indicate. (I do not accept Schlosser's view that the Ursidæ are descended from *Cephalogale* or *Cynodon*. The basicranial characters of these two genera exclude them, I think from ursid ancestry.) The cranial characters and foot construction of *Hyænarctos* would afford the critical evidence on which the question of its exact relationship to the Amphicyonines might turn; but unfortunately, although a skull of *Hyænarctos* has long been known, it is very imperfect in the cranial region, so that its basicranial characters apparently cannot be determined; and the foot structure of the genus is unknown. Nor have we complete data on the foot structure of any of the larger Amphicyonines. The astragalus, calcaneum, and a metapodial of *A. giganteus* and the skeletal material referred to *Pliocyon* enable us to reconstruct it in part. The fore and hind foot material described by Schlosser as *Amphicyon* belong to a much smaller animal, very different in foot proportions. More nearly related, although still much smaller and more primitive, is *Daphænodon* of Peterson. These genera may represent intermediate stages through which the large and specialized *Amphicyon* and *Pliocyon* arose from the Oligocene *Daphænus*.

In 1902 I referred to *Amphicyon sinapius* a part of the skeleton No. 9356 from the Pawnee Creek beds, which includes a humerus, ulna, nineteen dorsal and lumbar vertebræ and ribs, and a few caudals. To the same species were referred No. 9355 a number of bones found together in a wash mixed with other genera (*Dromomeryx*, etc.). These include the astragalus, parts of radius and tibia, but no skull parts. The lower jaw fragment and astragalus No. 8248, described nearly fifty years ago by Cope as a gigantic Canid are likewise to be referred here. While these remains are probably *Amphicyon*, they may very well belong to a larger species than *A. sinapius*.

In the Snake Creek beds there are isolated bones which agree very nearly with the foregoing in size and characters and belong probably to

the genus. Others, similar in type but of smaller size, are probably *P. medius*. These are, chiefly or all, from the lower horizon.

In the upper horizon at Snake Creek an equally gigantic carnivore is represented by a calcaneum and other fragments which indicate a long compressed pes. This is the horizon from which *Hyænarctos* is to be expected and an upper tooth found by Mr. Harold Cook undoubtedly represents that genus, although its horizon is not recorded. Possibly this elongate pes belongs to *Hyænarctos*, but it is not at all ursoid and I think it more likely that it is a gigantic true cat. There is also from the Snake Creek a huge scapholunar bone, too large to agree well with *Pliocyon*, possibly also referable to *Felis*. In the Republican River beds I have seen a humerus and other remains of a huge carnivore evidently distinct from *Pliocyon* and possibly this same Ursid or ? Felid.

The bones referred to *Amphicyon* and *Pliocyon* from Pawnee Creek and lower Snake Creek include therefore, vertebræ and ribs, the humerus, radius, ulna, tibia, astragalus and calcaneum, and more doubtfully, some metapodials. The humerus is of moderate length, with deltoid crest vestigial, broad inferior end with strong entepicondylar bridge, the radial facet convex, not flattened as in (?) Ursidæ. The ulna and radius are massive and rather short, the olecranon rather short, not turned backward, the radius with deeply concave distal facet and massive styloid process. The tibia also is short, its trochlea of moderate depth; the astragalus is wide but not so wide and short as in Ursidæ, comparable in proportions with *Smilodon* but with no trace of the astragalar foramen, neck short and navicular facet broadly convex. The calcaneum is broad, with the heel massive but not very long, the cuboid facet deeply concave. The tarsus is by no means so broad and short as in *Arctotherium*, but it is somewhat broader than in *Smilodon*, although the astragalus has a deeper trochlea and no foramen, and it is quite in contrast with the narrow, compact, elongate pes of *Canis* or *Ælurodon*.

The tail is very long and massive, as in the Oligocene Canidæ and in *Daphænodon*.

The type of *Pliocyon* (*Dinocyon*) *gidleyi* from the Clarendon of Texas consists of the skull, jaws, articulated backbone and femur, described and figured in 1902. This is in very hard matrix and the basi-cranial characters could not be determined. The vertebral proportions conform with those of *A. sinapius*.

AFFINITIES OF THE AMPHICYONINÆ.—The series of resemblances throughout the skeleton between the Oligocene *Daphænus*, the Lower Miocene *Daphænodon*, and the Upper Miocene *Amphicyon* and *Pliocyon*,

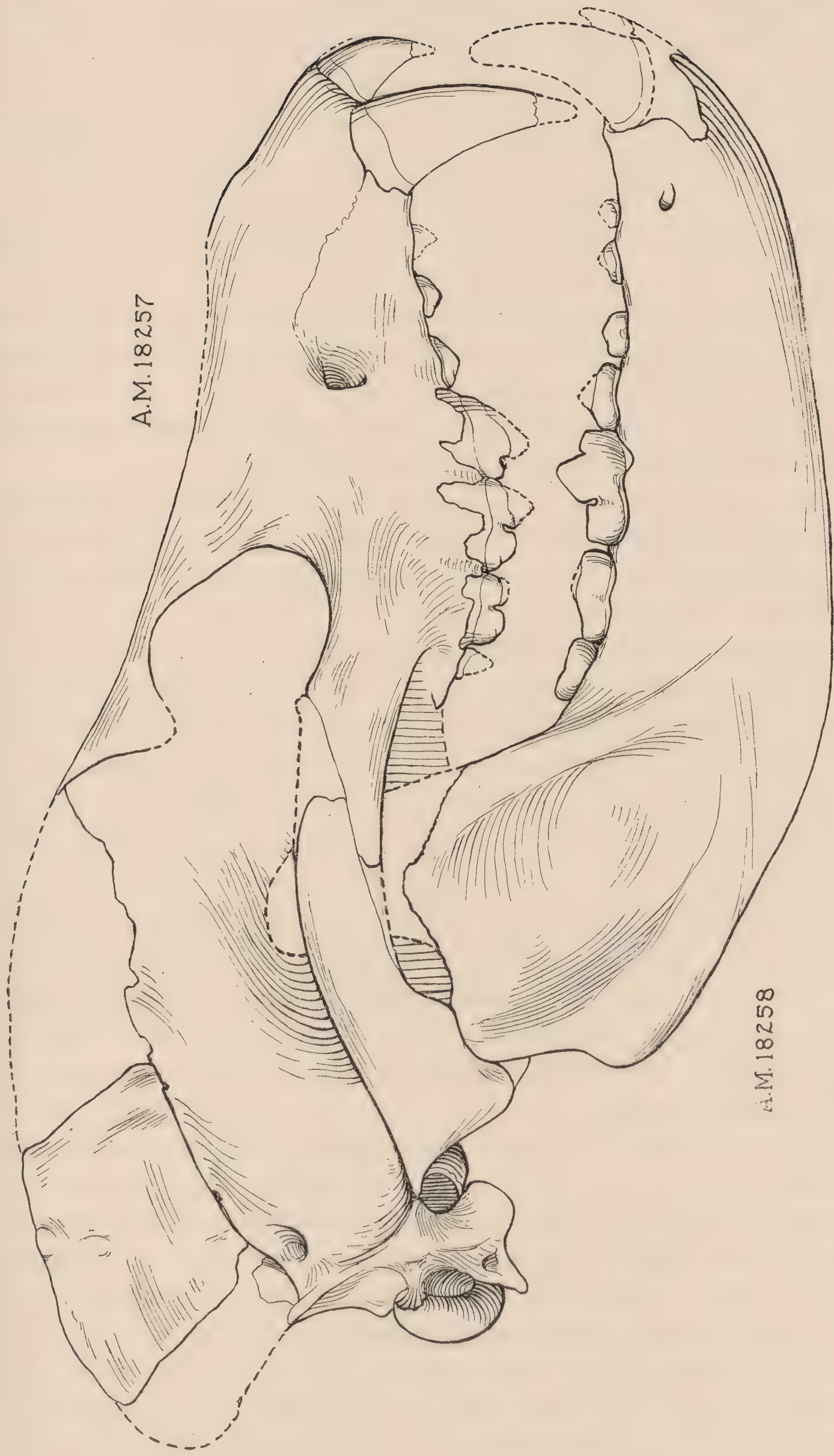


Fig. 27. *Amphicyon sinapius*; reconstruction of skull and jaws, three-eighths natural size, from Nos. 18257 and 18258, both from Snake Creek beds, *M. primus* zone.

leave no room for serious question that they form an approximate phyletic series, with which should also be placed *Dinocyon*, possibly other genera.

Structurally these genera are distinguished by

1.—Progressive enlargement of molars and reduction of premolars and carnassial; metaconid of lower carnassial well developed and heel basined, but with crests rather than cusps; tendency to retain m^3 .

2.—Skull rather elongate, with high sagittal crest and narrow occiput.

3.—Tympanic bulla small and limited to the anterior part of the otic region; a wide space between it and the paroccipital, with a prominent lateral protrusion of the mastoid.

4.—Cervical vertebræ relatively short, dorsals small with high spines, lumbar large and moderately long. Ribs short.

5.—Limb bones massive, proportioned much as in *Machærodontinæ*, feet pentadactyl, rather short, probably digitigrade and symmetrical in all stages, certainly in the older ones. Claws slightly retractile in older stages, unknown in later.

From the more typical *Canidæ* this amphicyonine group is set off primarily by the peculiar tympanic bulla. From the known *Ursidæ* it is sharply distinguished by the median symmetry of the feet, much narrower and more sharply grooved astragalus, long lumbar region, high spined dorsals, high narrow cranium and different type of bulla, as well as by the well-known differences in the teeth, which are partly bridged over by *Hyænarcos*, etc.

From the *Machærodonts* and *Felidæ* the *Amphicyonines* are distinguished first by the very different teeth, then the widely different bulla and other skull characters. The skeleton is not so obviously different, but the progressive specialization of the feet seen in both felid and machærodont phyla, centering about the sharp, retractile claws, is not seen in the *Amphicyonines*.

RELATIONS TO OTHER GENERA OF CANIDÆ.—In contrast with this highly aberrant group of the later Tertiary may be placed the Pliocene genus *Ælurodon*, which, in spite of its aberrant upper carnassial, is a typical dog, closely related to *Canis* in all details of skull and skeleton construction. The late Miocene genus *Tomarctus* is intermediate and ancestral to both genera, so far as the skull characters show.

The Lower Miocene *Cynodesmus*, also known from complete skulls and skeletons, is decidedly more primitive as to dentition than *Tomarctus*, the carnassial shear oblique and not yet showing the anteroposterior direction characteristic of typical *Canidæ*. The feet also are much more

primitive, moderately long, pentadactyl, metapodials little appressed, claws acute; and the brain is much smaller and simpler. The basicranial structure shows a large inflated bulla, reaching back to the paroccipital process, and in general may stand as ancestral to the typical Canidæ.

Among the Oligocene Canidæ, *Pseudocynodictis* of the White River and John Day is the most typical and best known; the skull and skeleton have been described by Cope, Scott and the writer, and it has been regarded as not far from the typical phylum. The tympanic bulla in this genus also is large and reaches back to the paroccipital, but it is not so solidly united as in later Canidæ and is not infrequently lost in the fossil skulls. It appears on the whole to be decidedly nearer to the ancestry of *Cynodesmus* and *Tomarctus* than is *Daphænus*, with its small bulla and amphicyonoid teeth.

Temnocyon and *Enhydrocyon* of the John Day may be considered as representative of a line leading into *Cyon* and its relatives; and for this there is much to be said, although neither appears to be in the direct line of descent; but a more critical study of their basicranial and foot structure, and a better knowledge of the very fragmentary remains, apparently intermediate, found in the American Miocene, would place this phylogeny upon safer ground. *Mesocyon* of the John Day appears to be intermediate between *Temnocyon* and *Cynodesmus* but more nearly related to the latter. Both are supposed to be descended from the White River genus *Daphænus*, which, in that case, would be the common ancestor of both the typical and the amphicyonine dogs. But it has not been shown that *Pseudocynodictis* can be excluded from the direct ancestry of the Caninæ, which it approaches more nearly than does *Daphænus* in the loss of m^3 , the basined heel of the lower carnassial, the large bulla and the more slender limbs and compacted metapodials. A thorough and impartial anatomical study of the abundant material of Oligocene and Lower Miocene Canidæ now available would be necessary to decide upon these relationships.

Professor Boule has maintained the view that *Cynodictis* is ancestral to the foxes and *Amphicyon* to the wolves, a view involving an incredible degree of convergent evolution. In his recent memoir¹ he indicates, however, that it is not from the typical Amphicyons of the later Miocene and Pliocene that he would derive the Canidæ, but from the primitive ancestral forms (presumably *A. ambiguus*, etc.), which are, in fact, closely related to the better known *Daphænus*; but he still appears to

¹'Les Grottes de Grimaldi,' Geol. et. Pal., pp. 245, 254. Boule, Marcellin, 1919.

maintain the foxes as independently derived from *Cynodictis*. Even this appears to me wholly improbable, and no real evidence has ever been adduced in support of it. It is of course quite possible to select species of fox and wolf respectively, displaying the superficial adaptive characters that belong with their respective sizes and food-adaptations, at every stage of the later Tertiary history of the Canidæ, and if these are imperfectly known and only the fragmentary dentition is studied, one can construct therefrom parallel series more or less plausible. But when one studies carefully the dentitions, skull and skeleton construction of modern wolves and foxes, they are evidently very closely related indeed, and their common ancestor cannot be very distant geologically. The diversity in dentition between different species of *Tomarctus* is quite as wide as among the wolves, jackals and foxes; and any one of these is more readily derivable from one or another species of this genus than from any other known Canid of the later Tertiary. The basicranial and other skull characters of *Tomarctus* are close to those of the modern wolves and foxes—the larger species to the wolves, the smaller to the foxes, those of intermediate size to the jackals. There is no reason to go outside of this genus for the ancestry of the group. *Galecynus*, which M. Boule specifies as an independent ancestor for the foxes, is decidedly more remote in what is known of its dentition and skull characters, and its feet are very different from those of any of the modern Canidæ. While the feet are not known in *Tomarctus* from any positively associated materials, there is every reason to refer to this genus various fragmentary remains like those of *Æluroidon* but smaller; and the feet of *Æluroidon*, a genus known to be closely related to *Tomarctus* (see p. 90) are quite modernized and differ but little from those of the wolf.

The modern South American Canidæ, with the exception of *Icticyon*, likewise appear to be directly derivable from *Tomarctus* or from the closely related *Leptocyon* (a doubtfully distinct genus). *Icticyon*, along with *Cyon* and *Lycaon*, are more distantly related; their crushing teeth are reduced in numbers and size, the lower carnassial has a trenchant heel (always bicuspid in the typical dogs) and no metaconid, the skull is short and the limbs and feet of less cursorial type (except *Lycaon*). The ancestry of the *Cyon* group has been traced back to *Temnocyon* of the Upper Oligocene and Lower Miocene, thence to *Daphænus*. *Temnocyon*, however, is perhaps less directly in line than *Enhydrocyon*, although this genus is somewhat precociously specialized in reduction of the teeth. The imperfectly known *Philotrox* of the John Day is perhaps more directly ancestral. The group may in my opinion be better derived from *Pseudocynodictis* than from *Daphænus*.

Palæontology gives no evidence as to the ancestry of *Otocyon*. This genus, while unique in the extra upper and lower molar, and peculiar in the development of the crushing dentition, is not so aberrant in other osteological features as one might expect; and probably represents not so much a stock of ancient differentiation from the rest of the Canidæ as a peculiar aberrant adaptation based upon an abnormal "mutation." In this connection it may be noted that the type of *Amphicyon frendens* shows on one side a partly preformed fourth lower molar (not shown in the figure) probably a reduplicated m_3 . Similar reduplication among modern Canidæ has been recorded several times.

The relationships of the Ursidæ turn, in my opinion, upon more adequate data and study of the skull and skeleton of *Hyænarctos* and other Tertiary genera. The phylogeny proposed by Dr. Boule (*loc. cit.*, p. 254) derives them, following Schlosser's views, from *Cynodon* and *Cephalogale*. The evidence in its support is wholly derived from the dentition and it is not at all in accord in many particulars with the evidence from cranial and skeletal characters where these are known. The basicranial characters of *Cephalogale* are cynoid, those of the Amphicyonine dogs are sub-ursoid. *Arctotherium* in Dr. Boule's view is derived, along with *Æluropus*, from *Hyænarctos*, while the true bears are derived from *Ursavus*. But *Arctotherium*, even in its dentition, and very clearly in all the essential details of its basicranial features, foot-construction, etc., is a true bear, very close to the typical group; *Hyænarctos* is much more remote. There is no reason why *Arctotherium* should not be derived from *Ursavus* or even a later stage of typical Ursidæ. *Dinocyon* and *Hemicyon* are too little known for any positive conclusions as to their real affinities; and *Cephalogale* has less apparent affinities to the bears than have some of the amphicyonine dogs. The real ancestry of the Ursidæ is probably to be found in future discoveries in Asia, not in the known genera of Western Europe or of North America, in both of which countries they appear after the manner of immigrants from a common intermediate region of dispersal, not as the result of evolution *in loco*.

The Phylogeny of the Canidæ

As a preliminary to any remarks on this subject, I must express my total disbelief in the fundamental classification of the Canidæ into an "alopecoid" and a "thoïd" series proposed by Huxley in 1880 and accepted by Boule, Scott, and various other later writers. In the main this distinction is one due to size; the thoïds are medium and large, the

alopecoids medium and small, Canidæ. The larger Canidæ have relatively smaller brains and relatively larger muscular attachments, as is necessarily and for excellent mechanical reasons the case in any contemporary series of species in any group of mammals or reptiles, living

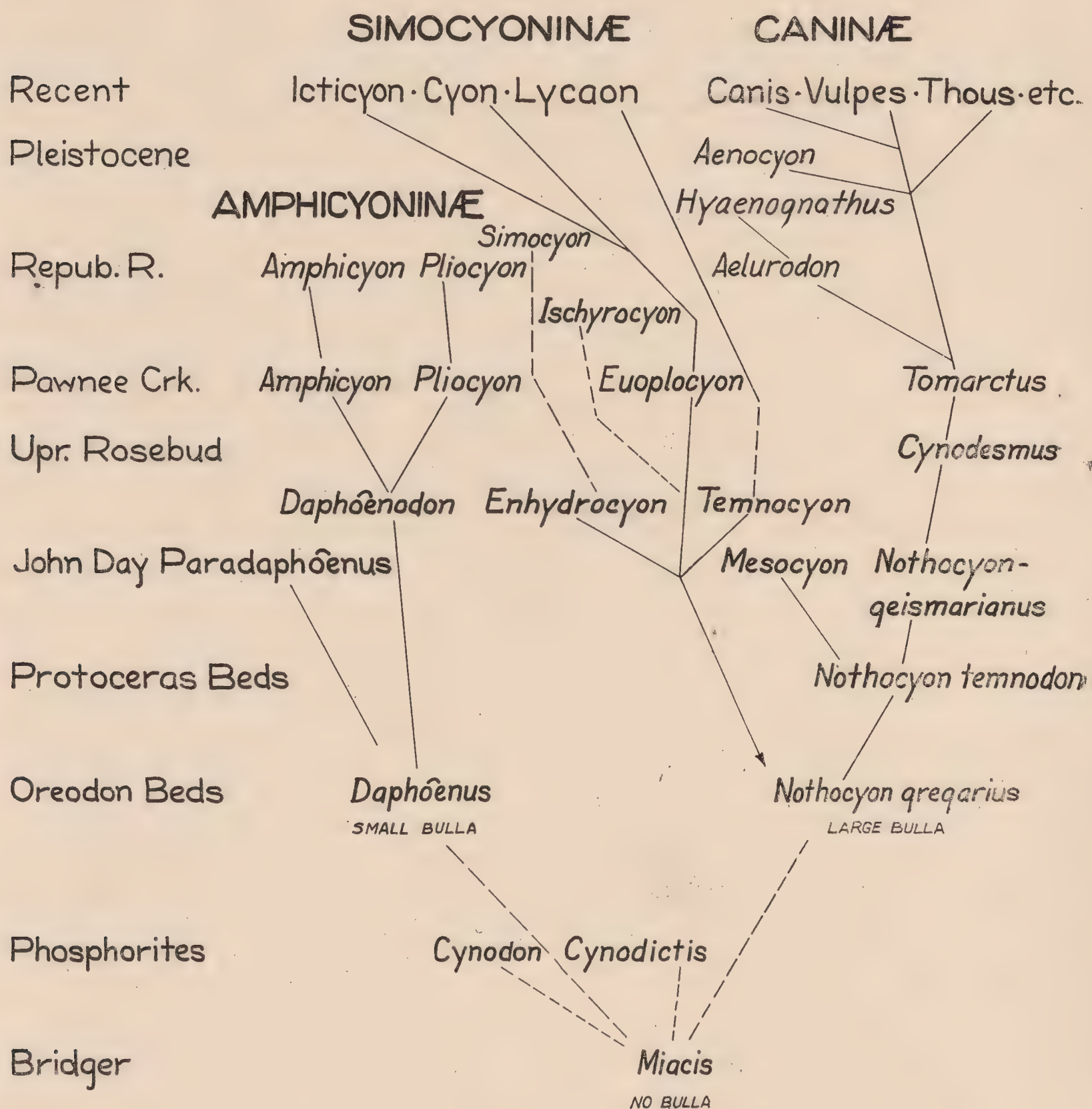


Fig. 28. Phylogeny of the Canidæ.

The lines represent the affinities of the genera as a whole but the known species are usually rather approximately than directly in the line of descent. Dotted lines show very doubtful affinities.

or extinct. There is, therefore, in the Canidæ a necessity for building out the skull at certain points to provide suitable attachments for the muscles, and a vacant space results, which is usually filled by separating the inner and outer table of the bone and providing sinuses or other skull spaces. It is for this reason that the sagittal and occipital crests, the

zygomatic arches, the postorbital processes, are built out and relatively prominent in the larger species. The brain is relatively smaller than in smaller related species in the same grade of evolutionary development.

But the brain is also relatively smaller in species of the same size but in a lower stage of their evolution. Such species may be earlier geologically, inhabiting the same zoölogical regions. Or they may be contemporary geologically but inhabiting more marginal portions of the area of dispersal of the group. We should expect therefore to find that both the Canidæ of the later Tertiary in the northern world, when directly or approximately ancestral to the modern species, and also the existing Canidæ in the marginal southern continents, although smaller in size, resembled larger existing species of the northern world in those features which are due to building out of the skull and relative smallness of the brain.

This is exactly what we find in such obvious characters as the sagittal crest, the width and weight of the zygoma, prominence of the postorbital processes, etc., and I think it sufficiently explains the distinction on which Professor Huxley laid so much weight in the presence or absence of frontal sinuses. They are present in all the large modern Canidæ, absent in all small modern Canidæ. That they are present in South American and in certain African and Oriental Canidæ of medium size, while absent in Holarctic Canidæ of equal size, was taken by Huxley to be proof that it was not due to size and must therefore represent a real taxonomic distinction. But, as I interpret it, this is merely an indication—one of many—of the somewhat primitive character of these species of marginal regions in the geographic range of the group. If it were practicable to section skulls of all the extinct Canidæ, I have little doubt that such sinuses would be found to be present in the larger species and not in the smaller species of each of the earlier stages, but that, like the sagittal crest and other external characters, they would be found more prominent in species of the same size but at an earlier stage of evolution.

Tomarctus brevirostris, about the size of the coyotes, has the sagittal crest and other building-out features of the skull quite as prominent as in the timber-wolf. *T. confertus*, about the size of the fennec, has these features as much developed as in the coyotes. In the Oligocene one finds the smaller Nothocyons, *N. gregarius*, *lemur*, *latidens*, without sagittal crest, but they are much smaller than any modern Canids; and *N. temnodon* or *geismarianus*, although comparable in size to the fennec, have well-developed sagittal crests. I do not doubt that the smallest species of *Cynodictis*, *Nothocyon*, *Cynodesmus*, and *Tomarctus* are “alope-

coid" throughout, as they obviously are in the external features of the skull, while the larger species of each genus are as obviously "thoöid." But when the larger and the smaller species in each genus are obviously closely related by innumerable constructive details in the teeth, skull and skeleton, the simple mechanical explanation which I have outlined appears to be the only one reasonably possible. To suppose that the larger and smaller species of each genus are successive representatives of phyla distinct since the Eocene would involve an incredible degree of parallelism in their evolution, violently in contrast with the divergent evolution of numerous other phyla in the Carnivora and other groups and altogether unnecessary to believe, as the evidence adduced in support of it appears to be unsound.

On the other hand, there is throughout the species of both thoöid and alopecoid Canidæ—excepting *Cyon*, *Lycaon*, *Icticyon* and *Otocyon*—a remarkably close accord in the details of construction of the teeth, extending also to the skull and skeleton, which appears to me to afford very strong evidence for their near relationship.

It is to be observed that when Professor Huxley wrote, in 1880, very little of the present evidence from the geological record was available. Had he had before him the series of skulls of Tertiary Canidæ which it has been my privilege to study and compare in recent years, one may presume that he would have given first place to their evidence, interpreting the "thoöid" and "alopecoid" characters on lines conforming to it.

Huxley's deservedly high authority has, however, afforded what I believe to be a wrong starting-point for the later researches of two very able palæontologists, Professor Boule and Professor Scott, both of whom have been disposed to attach great importance to the distinction between the alopecoid and the thoöid Canidæ. Boule has been disposed to derive the thoöid division from *Amphicyon*, the alopecoid division from *Cynodictis*. Scott, while deriving the thoöids from *Daphænus* through *Cynodesmus*, has been somewhat obscure as to the derivation of the alopecoids. The present writer has consistently taken the view (since 1899) that the distinction between thoöids and alopecoids is an unnatural division and that the real division among the modern Canidæ lies between the genera *Cyon*, *Icticyon* and *Lycaon* on the one hand, and the remainder of the Canidæ on the other, which form a nearly related natural group, exclusive of the peculiarly aberrant *Otocyon*.

It very frequently happens in mammalian taxonomy, especially in dealing with fossil material, that some minor characters in the dentition are found to run very constant through a large series of species or speci-

mens, and to be regularly associated with other much more important characters which are either less constant or less often observable, particularly in the fossils. Such is the case in the Canidæ with the character of the heel of the lower carnassial. It can be observed on a very great number of specimens and certain constructions found to run constant throughout a large series of species which vary widely in size, in superficial skull characters, in proportions of the teeth, etc.; while certain differences in this construction are as constantly associated with differences in the number and construction of other teeth, in the proportions of the skull, in the construction of the basicranial region, in length of limbs and tail, length and characters of the feet, etc., which are of much more importance in the economy of the animal but are either less constant or less often observable, especially in extinct species. For this reason such minor distinctions are practically convenient in tracing the relationships and evolution of the species, although they are quite incidental or of minor importance in the adaptive specialization of the phyla.

All the typical modern Canidæ have a bicuspid heel on m_1 , the outer cusp or hypoconid being more or less tetragonal or rounded, while the inner cusp or entoconid is a fairly distinct cusp, with or without a marginal crest enclosing a "basin." On the other hand, in *Cyon*, *Icticyon* and *Lycaon* the heel of m_1 is crested, the hypoconid almost median in position; it is an anteroposterior crest instead of a tetragonal cusp and the entoconid and inner cingular ridge are absent, so that the heel is not at all basined. This is associated in these genera with a reduction of the tubercular part of the dentition (behind the carnassial shears), a tendency to reduce the second lower molar to a similar longitudinal crest, to drop the last lower and last upper molar, absence of the conules of the upper molars, prominence of the heels and accessory cusps on the premolars and incisors, a relatively short face and short high skull and (except in *Lycaon*), shorter limbs and feet less specialized in the direction of cursorial adaptation. *Lycaon*, however, is more and not less specialized in some of its cursorial adaptations, notably the reduction of the pollex. In all the modern Canidæ the tympanic bulla is of characteristic type, large, inflated, nearly simple, without bony auditory meatus, extending from the eustachian opening and anterior lacerate foramen to the paroccipital process, which is long, rather slender, points downward, and is suturally united to the back of the bulla.

Tracing the palæontologic record of the family we find that nearly all the Pleistocene species belong to the typical group; but that in the

South American Pleistocene skulls and jaws have also been found of the *Cyon* type. Fragmentary remains were described by Lund as *Palæocyon* and *Speothos* and a good skull was figured by Lydekker as *Canis morenoi*. Remains of *Cyon* have been found in the Pleistocene of southern Europe. *Lycaon* has been wrongly identified in England from an uncharacteristic fragment, but occurs in the Pleistocene of France and Italy.

In the Pliocene and later Miocene many species of the typical group of Canidæ are known. The most completely known are *Canis megamastoides* of the later Pliocene of France, a fox-like type which Doctor Boule has considered, probably correctly, as a fairly direct ancestor of the foxes; and *Ælurodon* of the lower Pliocene of this country, which is aberrant in certain features, notably the strong development of the parastyle on p^4 and the short, massively proportioned premolars. In these particulars it parallels the hyænas; in the marked prominence of the frontal region it parallels the domestic dogs as opposed to all wild species, and in the comparative reduction of the tubercular dentition it tends toward the *Cyon* group (as do also the modern true wolves). But in the basicranial characters, the proportions and specializations of the limbs and feet, *Ælurodon* is a perfectly typical Canid and it is evidently closely related, although not directly ancestral, to the modern typical Canidæ.

Perhaps related to *Ælurodon* but more aberrant, is the California Pliocene *Hyænognathus*, known from an imperfect skull and a lower jaw (*Porthocyon*) doubtfully identical.

A little older than *Ælurodon*, in the later Miocene, we find the genus *Tomarctus*, which appears to be more directly ancestral to the typical Canidæ, but also to *Ælurodon*, for it displays in a minor degree all the peculiarities which *Ælurodon* has accentuated and the modern dogs have lost. The skeleton of *Tomarctus* is not fully known, but in the skull and what is known of the skeleton it appears to be a typical Canid, although less specialized in numerous details.

A few jaws and teeth in the upper Miocene of this country appear to be related to the *Cyon* group. They have the characteristic crested heel and absence of metaconid on m_1 , agree also in reduction of the tubercular teeth, prominence of accessory cusps on the premolars, etc., but the skull and skeleton are unknown.

Another questionable type, known only from an immature lower jaw, is *Ischyrocyon*, in which m^1 has the crested heel without metaconid, but the tubercular dentition is very large relatively and the premolars much reduced in size and simple in construction. This may perhaps belong rather to the *Amphicyon* group.

A second important group of Canidæ of the later Tertiary is the *Amphicyon* group found both in Europe and this country. These are distinguished by a heel on m_1 that has a large crested hypoconid but more external in position, and an inner entoconid crest more or less strongly developed; the metaconid of m_1 is large and the heel and all the tubercular dentition very large, while the carnassials and premolars are proportionately reduced. M^3 is present on *Amphicyon*, lost in the related *Pliocyon* and *Dinocyon*.

The skull and especially the skeleton of *Amphicyon* differ widely from the typical dogs and the *Cyon* group. The skull has various primitive characters but the most important distinction is in the tympanic bulla, which is much more suggestive of bears or mustelids than of dogs. It is small, only partly inflated, with a long bony auditory meatus and it covers only the anterior half of the otic area, being wholly in advance of the mastoid process and at some distance from the paroccipital process.

The skeleton of *Amphicyon* is still less like that of the dogs; in most characters it has rather specialized in an opposite direction from the primitive carnivore type. The back and neck are heavy, arched somewhat as in the bears; the tail is very long and massive, more so than in almost any living carnivore; the limbs are short and powerful, the feet broad and spreading, five-toed, apparently digitigrade (unlike the bears), the claws compressed and sharp, somewhat between cat and bear in type. This was a very extraordinary animal, as different from living dogs as a badger or an otter from a weasel, and not much like any other carnivore.

Nearly related to *Amphicyon* are *Pliocyon* and *Dinocyon*, in which the last molar has been lost.

In view of such wide differences from the typical dogs of the Miocene, the earlier opinion of Dr. Boule that modern thoïd Canidæ are descended from *Amphicyon* and the foxes only from the typical Tertiary Canidæ appears quite untenable, and he has more recently modified it to the extent of deriving the thoïds from smaller and more primitive Oligocene species referred to *Amphicyon* by European writers. This has been considered above (p. 121).

In the Upper Oligocene and Lower Miocene we find at least three groups of Canidæ, which are ancestral apparently to the true dogs, the *Cyons*, and the *Amphicyons*, and fortunately we have skulls and skeletons of all three. The first is represented by a considerable number of species referred to two closely allied if not identical genera, *Cynodesmus* Scott and *Nothocyon* Matthew. These range in size from a fox to a marten

and, although typically canid in the bulla, are decidedly more primitive in many features of their dentition and still more so in skull and skeleton. With these are larger and more robust animals, *Enhydrocyon* and *Temnocyon*, which have the *Cyon* peculiarities in the dentition but are more primitive than *Cyon* in skull and skeleton. They also have the typical bulla. The third is *Daphænodon*, which is in all respects allied to *Amphicyon* but smaller and less specialized throughout. There are also smaller related species referred to *Paradaphænus*.

In the Middle and Lower Oligocene we find two genera, likewise known from the entire skeleton, *Pseudocynodictis* and *Daphænus*. The first has the large bulla of the true dogs, the second has the bulla like that of *Amphicyon* save for lack of ossified meatus. In both genera the bulla is very loosely attached to the skull and often lost. There is not any wide difference between them in dentition, skull and skeleton, but each shows the early stages of the characteristics of the true dogs and amphicyonine dogs respectively. *Daphænus*, which seems to be the ancestral type of the *Amphicyon* group, retains the last upper molar but in "*Cynodictis*" this last upper molar is already lost.

In the Eocene we have a common ancestral type in *Miacis* and possibly in different species of *Miacis* we can trace the earliest division between true and amphicyonine dogs, in the vestigial m^3 of *M. sylvestris* and the more functional m^3 of *M. medius* and other species. Unfortunately, the bulla is no longer available to confirm this suggestion, as it does not appear to have been ossified in the Eocene Miacidæ; and while the parts of the skeleton known in each conform to the distinctions between *Cynodictis* and *Daphænus*, they are not sufficiently diagnostic to be decisive.

MUSTELIDÆ

The number and variety of mustelids in the Miocene and Pliocene is very large and the species incompletely known, mostly from lower jaws, so that it is very difficult to systematize or even to correlate them. They do not appear to be in any large proportion closely related to the modern types. Some have been referred to existing genera, but usually because there are no sufficient generic distinctions apparent in the lower jaw. Among the dozen complete lower jaws in our Snake Creek collections, hardly two are enough alike to be considered conspecific; and the correlation of the upper with the lower dentition is by no means certain in some cases.

The Oligocene Mustelidæ all have sharply trigonal viverroid dentition and their true relations to the contemporary viverroid and cynoid

genera are by no means certain. Père Teilhard's very able and thorough revision of the Quercy genera presents a conservative estimate of the possible and probable relationships of the various groups.¹ The relationship of the American Oligocene genera (*Oligobunis*, *Bunælorus*, *Parictis*) is less open to question, but turns mainly upon the musteloid characters of the carnassials (protocone of p⁴ sharply offset, crest of heel of lower carnassial external), the simple structure of the premolars and the degree of reduction of the molars.

In the Miocene Mustelidæ the tendency to broaden the inner half of m¹, so characteristic of the later genera, becomes progressively apparent; and the characters of the basicranial region are clearly differentiated from those of Canidæ, Viverridæ or Felidæ. The family relationships are no longer in doubt; but the more exact systematic arrangement, even of the modern genera, is by no means agreed upon, and the position of the extinct genera is more or less provisional in many instances.

The following key is intended to set forth the more obvious distinctive characters in the teeth, especially of the American Tertiary genera, but does not always show even the provisionally accepted affinities. The first group, Mustelidæ with two functional molars, is believed to be a natural one; the second, of primitive Mustelidæ, probably represents, in the main, the ancestral group of the family but some of the genera are of doubtful affinities and may well be, as Teilhard shows, composites of variously related species. The third division includes all the modern Mustelidæ and is subdivided into three groups, the first comprising the wolverene, ratel and extinct associates, the second, the weasels, martens, etc., the third including a rather wide variety of insectivorous and piscivorous adaptations. These in turn are grouped into (1) the otters and skunks—which are obviously related in their dentition, however diverse in their food and habits; (2) the badgers, with a number of extinct genera more or less related, the most divergent of the extinct genera being *Leptarctus*, whose affinities are discussed later in this paper.

KEY TO THE PRINCIPAL GENERA OF MUSTELIDÆ

I.—Two upper molars.

A.—Metaconid of m₁ distinct, heel smaller, trenchant.

1.—M¹ not expanded on lingual side, m² very small.... +*Oligobunis*.

2.—M¹ expanded on lingual side, m² larger..... +*Canimartes*.

3.—Upper teeth unknown; near *Canimartes*..... +*Sthenictis*.

B.—Metaconid of m₁ large, heel large, basined.

+*Paroligobunis*, +*Brachypsalis*.

¹Teilhard de Chardin, Père P., 1915, 'Carnassiers des Phosphorites de Quercy.' Annales de Paléontologie, IX, pp. 103-192, Pls. I-IX.

II.— M^2 vestigial or absent, small primitive types with sharply triangular m^1 .

A.—Metaconid of m_1 small or absent, sectorial dentition compressed and sharp, tubercular dentition reduced, m^1 more extended transversely.

1.—A small metaconid on m_1 .

+*Stenogale*, +*Stenoplesictis*, +*Palæoprionodon*, etc.

2.—No metaconid on m_1 .

a.—A minute m^2 +*Bunælorus*.

b.— M^2 absent..... +*Palæogale*.

B.—Metaconid of m^1 well developed, teeth more robust with tubercular dentition larger, m^1 less transverse.

1.—Protoconid of m_1 considerably higher than metaconid.

+*Plesictis*, +*Parictis*.

2.—Protoconid of m_1 only slightly overtopping metaconid; m_2 elongate, procyonoid..... +*Amphictis*.

III.—One upper molar (except for a vestigial m^2 in *Megalictis*, *Ælurocyon* and *Potamotherium*). Lingual half of m^2 more or less expanded and other characteristic mustelid features.

A.—Premolars compressed, carnassials of shearing type, m^1 narrow, transverse, no metaconid on m_1 ; large animals with robust predaceous teeth. Wolverine group.

1.—Inner half of m^1 slightly expanded, m^2 vestigial.

a.—Three lower premolars, skull very short..... +*Megalictis*.

b.—Four lower premolars, skull more elongate..... +*Ælurocyon*.

2.—Inner half of m^1 considerably expanded, m^2 absent.

a.—Premolars somewhat compressed, unreduced..... *Gulo*.

b.—Premolars robust, $p_{\frac{1}{1}}$ absent..... *Mellivora*.

B.—Sectorial teeth sharp, compressed, tubercular teeth reduced, m^1 narrow, transverse; mostly small animals with predaceous teeth and vermiform bodies. Weasel group.

1.—Metaconid on m_1 of moderate size, premolars reduced.

a.—Talonid of m_1 crested..... +*Plionictis*.

b.—Talonid of m_1 basined..... +*Proputorius*.

2.—Metaconid of m_1 small, low set.

a.—Premolars unreduced..... *Mustela*.

b.—First premolar absent..... *Galictis*.

3.—No metaconid on m_1 , premolars shortened and reduced in number.

Ictonyx, *Putorius*.

C.—Premolars robust, carnassials with reduced shear, large metaconids and heels, tubercular dentition enlarged, m^1 more or less quadrate.

1.—Upper carnassial trigonal, no hypocone; heel of lower carnassial basined. Otters and skunks.

a.—Premolars $\frac{4}{4}$; m^2 vestigial..... *Potamotherium*.

b.—Three lower premolars (upper dentition unknown) . . +*Mionictis*.

c.—Premolars $\frac{4}{3}$; teeth more specialized throughout. *Lutra*, *Pteronura*.

d.—Premolars $\frac{3}{3}$; teeth very massive and extremely specialized.

Latax.

e.—Premolars reduced, shortened, acutely pointed.

Spilogale, *Mephitis*, *Conepatus*, etc.

- f.*—Muzzle elongate, slender, teeth much reduced.....*Mydaus*.
- 2.—Upper carnassial becoming tetragonal, with hypocone. Badgers.
 - a.*— M^1 much wider than long; hypocone of p^4 small, four premolars, strong postorbital crests.....*Helictis*.
 - b.*— M^1 fully quadrate, hypocone of p^4 strong, $p^1_{\frac{1}{1}}$ absent; heel of m_1 basined, strong postorbital crests.....+*Leptarctus*.
 - c.*— M^1 much expanded lingually, tubercular teeth more or less multicuspid, $p^1_{\frac{1}{1}}$ absent; a sagittal crest and wide occiput.
 +*Trochotherium*, +*Promeles*, *Arctonyx*, *Meles*, *Taxidea*.
 - d.*—Four lower premolars, skull unknown.....+*Trochictis*.

BRACHYPSALIS

This genus is still imperfectly known but it appears probable that it represents an extinct phylum, derived from *Oligobunis* through the Lower Miocene *Paroligobunis*, characterized by progressively more robust teeth, shortened jaws, enlargement of the tubercular and reduction of the sectorial dentition. Peterson has described part of the skeleton of *Paroligobunis*, which shows clearly that it is not related to the otters, to which the dentition suggests affinity.

In the Lower Snake Creek *B. modicus* is represented by a number of jaws and teeth and the larger and more massive *B. obliquidens* is also probably from this level. In the upper horizon a large species is represented by an upper jaw, No. 18268, with p^4 - m^1 and alveolus of m^2 . This may be *B. pachycephalus* but the materials are not sufficient for positive identification. It belongs more probably with the lower dentition described below.

?*Brachypsalis pristinus* (Matthew and Gidley)

Lutra pristina Matthew and Gidley, 1904, Bull. Amer. Mus. Nat. Hist., XX, pp. 256, 257, Figs. 7, 8.

The type of this species is a lower jaw from the Valentine beds, No. 10811. A lower jaw from Quarry C, Upper Snake Creek, No. 18922, agrees closely with the type and is referred definitely to the species but the generic reference is provisional, as the very incomplete type of Cope's genus differs considerably in the proportions of the teeth indicated by their shattered remnants or alveoli. The premolars are much more robust, the carnassial shorter and the second molar more elongate and two-rooted, as compared with ? *B. pristinus*.

B. pristinus differs equally from *B. modicus*, in which the heel of the carnassial is not so decidedly basin-shaped, p^4 has a distinct posterior accessory cusp, and the premolars are less crowded and reduced. If the upper jaw No. 18268 from the same quarry and level is *B. pristinus*, the

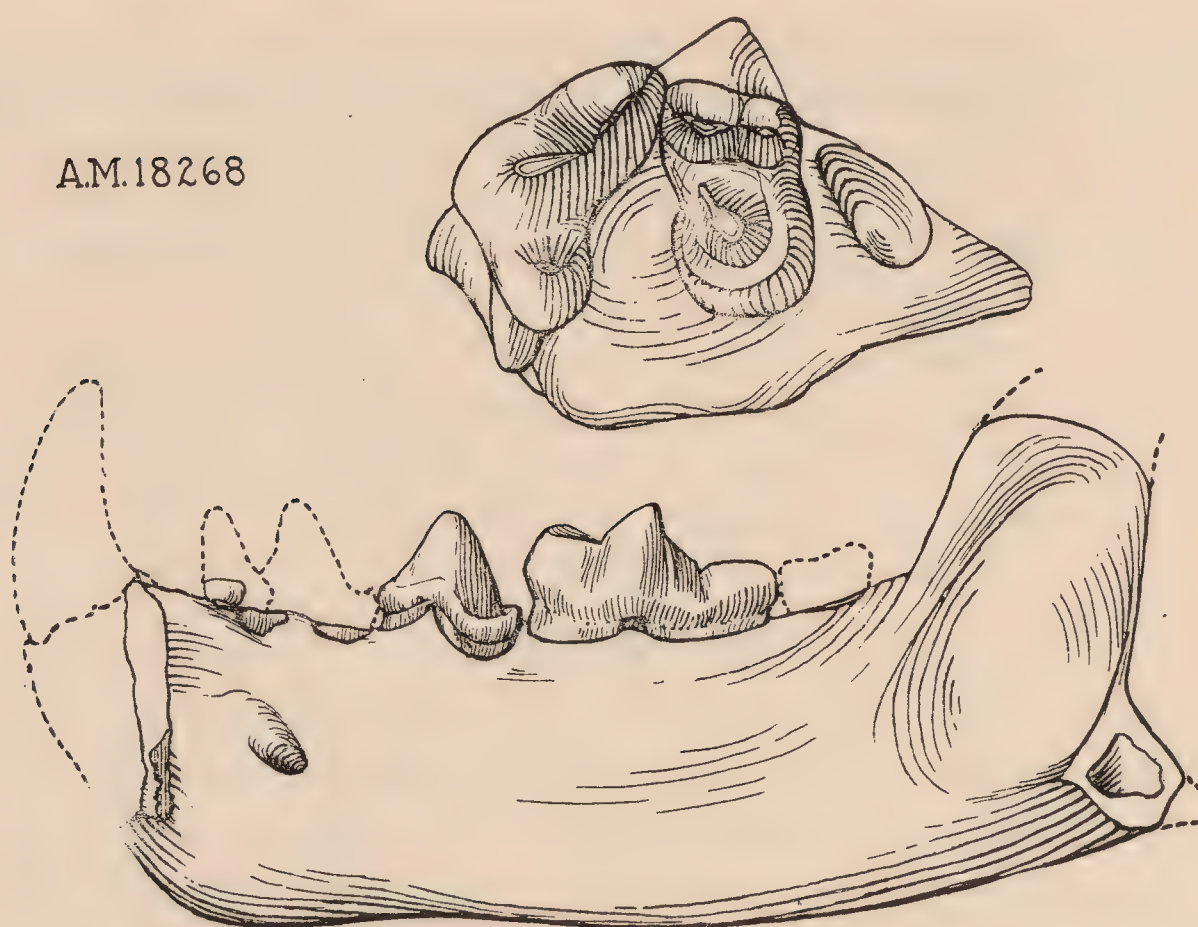


Fig. 29. *Brachypsalis pristinus*; upper and lower jaw, natural size, from Upper Snake Creek beds, Olcott Hill. No. 18268, crown view of upper teeth; No. 18922, external view of lower jaw of a smaller individual.

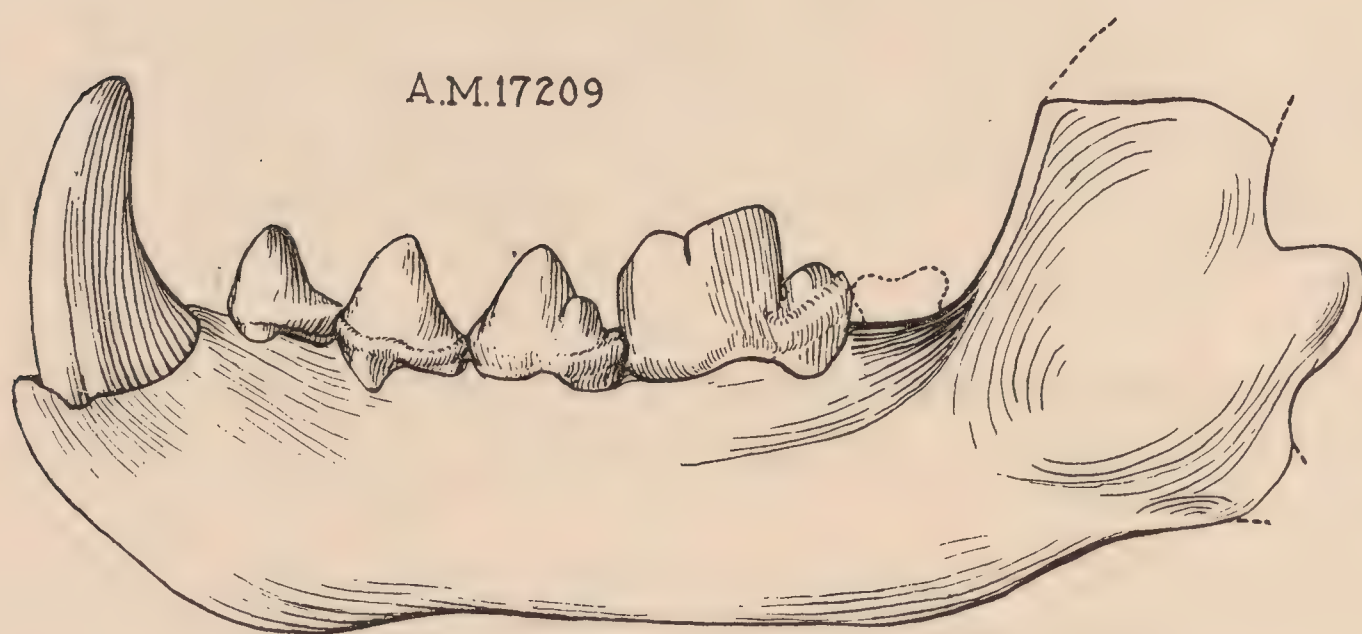


Fig. 30. *Brachypsalis modicus*; lower jaw, external view, natural size. No. 17209 (reversed), Snake Creek beds, *M. paniensis* zone.

upper teeth show corresponding differences of specialization from those of *B. modicus*. The carnassial is relatively short and massive, with posterior blade reduced and inner cusp broadened but still retaining its anterointernal position. The first molar is shorter transversely, more massive and quadrate. The second molar is relatively larger in No. 18268 than in *B. modicus* No. 17210, so far as one can judge from the alveoli.

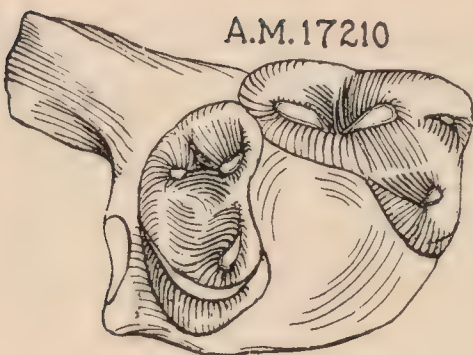


Fig. 31

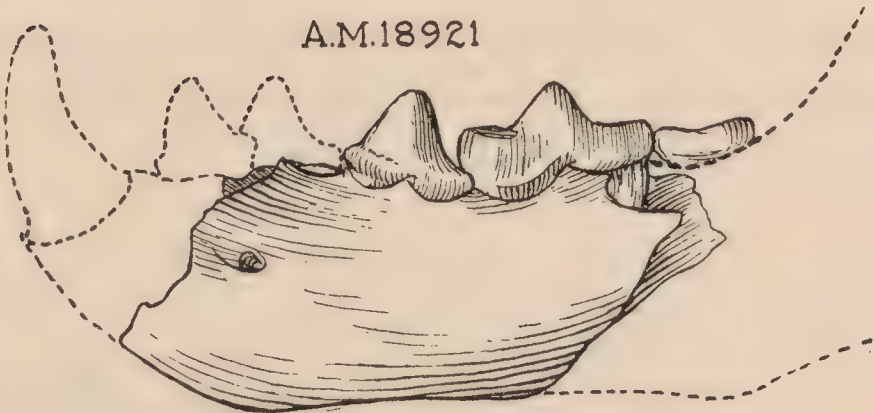


Fig. 32

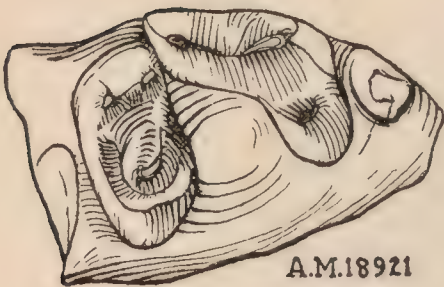


Fig. 33

Fig. 31. *Brachypsalis modicus*; upper teeth, crown view, natural size. No. 17210 (reversed), *M. paniensis* zone of Snake Creek beds.

Fig. 32. *Brachypsalis matutinus*; lower jaw, external view, natural size. No. 18921, type, Sheep Creek beds, *M. primus* zone.

Fig. 33. *Brachypsalis matutinus*; upper teeth of type specimen, No. 18921, natural size.

? *Brachypsalis matutinus*, new species

TYPE.—No. 18921, parts of upper and lower jaws from Stonehouse draw quarry, Lower Sheep Creek beds.

CHARACTERS.—One-seventh smaller than ? *B. modicus*. Premolars more reduced and crowded than in ? *B. pristinus*, much more than in *B. modicus*, the space between canine and p_4 scarcely exceeding the length of that tooth. P_4 simple, without accessory cusp; carnassial proportions as in *B. modicus*, but heel simply basined as in *B. pristinus*, lacking any separate entoconid. M_2 oval, the trigonid cusps still distinct and with normal basined heel, unlike the round crown of *B. pristinus*.

Length from back of canine alveolus to m, inclusive	28
Diameters of p_4 a-p $\times$ tr.	8 $\times$ 4.3
“ m_1 “	13.3 $\times$ 6.3
“ m_2 “	6.3 $\times$ 4.5
Depth of jaw beneath m_1	15.4
Diameters of p^4	9.2 $\times$ 12.7
“ m^1	7.3 $\times$ 12.4
Transverse diameter of alveolus of m^2	8.3

P^4 has the inner cusp somewhat more anterior in position than in *B. modicus*. The anterointernal flange of m^1 is more rudimentary and the parastyle crest is not developed, the whole tooth having a narrower and more pointed-oval form than in *B. modicus*. The difference from *B. pristinus* is much greater, but it resembles that species, as against *B. modicus*, in the lack of parastyle on m^1 .

This species might be referred to *Paroligobunis*, if Peterson’s genus were not so imperfectly known. It differs widely from *B. pachycephalus*;

B. pristinus and *modicus* are intermediate stages but the latter is clearly off the direct line of descent, if the series be considered as such, having a longer jaw, accessory cusp on p_4 , entoconid on heel of m_1 and metastyle on m^1 to distinguish it. Better knowledge of the dentition of the four species would probably show that they represent at least two, probably three distinct phyla.

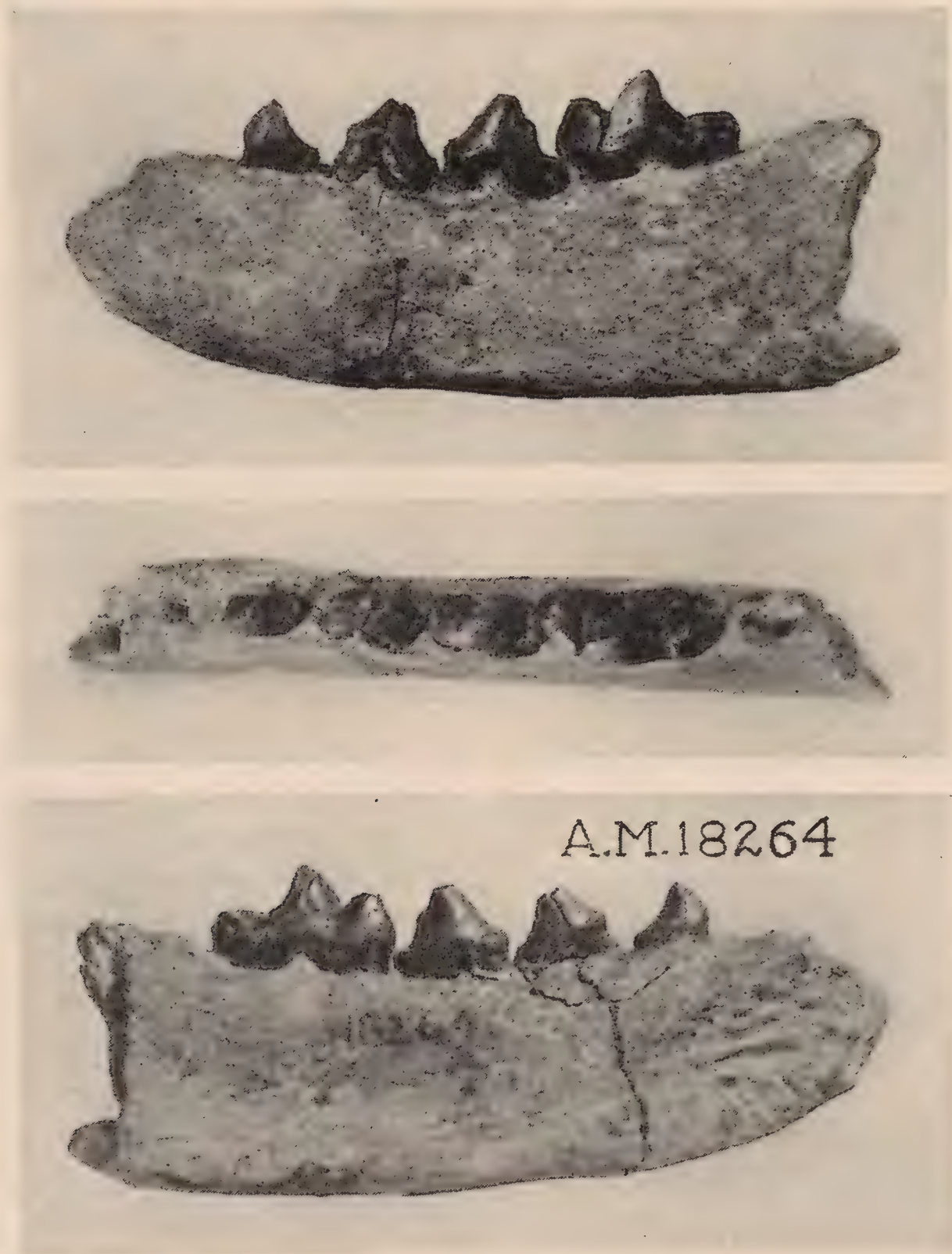


Fig. 34. *Sthenictis dolichops*; lower jaw, type specimen, natural size, external, superior and internal views. No. 18264, Snake Creek beds, *M. paniensis* zone.

STHENICTIS Peterson

The type of this genus is *Stenogale robusta* Cope. It appears to be related to *Brachypsalis* and to *Canimartes* Cope of the Blanco, but the data are so fragmentary that the genera cannot be clearly distinguished. The type of *S. robusta* is a lower jaw from the Valentine beds at Fort

Niobrara, Nebraska; it is distinguished from *Brachypsalis* by the somewhat narrower jaw with more compressed premolars, heel of carnassial narrower, smaller, with no entoconid, m_2 proportionally smaller.

***Sthenictis dolichops*, new species**

TYPE.—No. 18264, lower jaw with p_2 - m and alveoli of canine p_1 and m_2 , from lower level of Snake Creek beds, Sheep Creek Quarry, Expedition of 1921.

GENERIC CHARACTERS.—Dentition $\overline{?1.4.2}$. Canine large, incisors small or none. Premolars moderately compressed, a little spaced, p_4 with distinct heel and posterior accessory cusp. Carnassial compressed, metaconid small but somewhat less reduced than in *Mustela americana* and the whole tooth more massive. Posterior crest of metaconid continued down and around inner margin of talonid as in the preceding genus, but much less prominent. Hypoconid robust, somewhat external, slightly crested.

SPECIFIC CHARACTERS.—Size of *Cyon alpinus*, c - m_2 about 67 mm. Alveolus of m_2 round-oval, much larger than in *Sthenictis robustus*, more as in *Brachypsalis*. This is a peculiar type for a Mustelid, resembling the *Cyon* group in proportions of the jaw but with the simple premolars and sub-external hypoconid on m_1 that indicate its mustelid affinities.

The upper dentition is unknown and the genus may prove to belong in the group with two upper molars, near *Canimartes*.

PLIONICTIS, new genus

Between *Sthenictis* and *Mustela* intervene a considerable number of Miocene species, known almost wholly from lower jaws, whose association and affinities are very doubtful. The only one adequately known is *Mustela ogygia* of the Pawnee Creek beds; type, a skull and lower jaws. This differs from the true martens in the more distinct metaconid of m_1 , reduction of the anterior premolars and absence of p_1 on both sides of the lower jaw, of p^1 on one side of the upper jaw and other details; but it appears to be nearly related to the martens although, apparently, it should be distinguished generically.

M. glareæ Sinclair is closely related to *M. ogygia* but distinguished by retaining a minute p_1 and an accessory cusp on p_4 , both distinctions being perhaps obliterated by age on the type of *M. ogygia* and not valid specific distinctions.

M. parviloba from the Pawnee Creek is of larger size but otherwise nearly related, if the reference of No. 17208 from the Lower Snake Creek to this species is correct.

These three species may be associated as a genus of Mustelinæ related to the martens but with strong metaconid, less expansion of the inner half of m^1 , jaw shortened and premolars reduced and crowded or p_1^1 absent, a distinct sagittal crest. *P. ogygia* is the type of the genus.

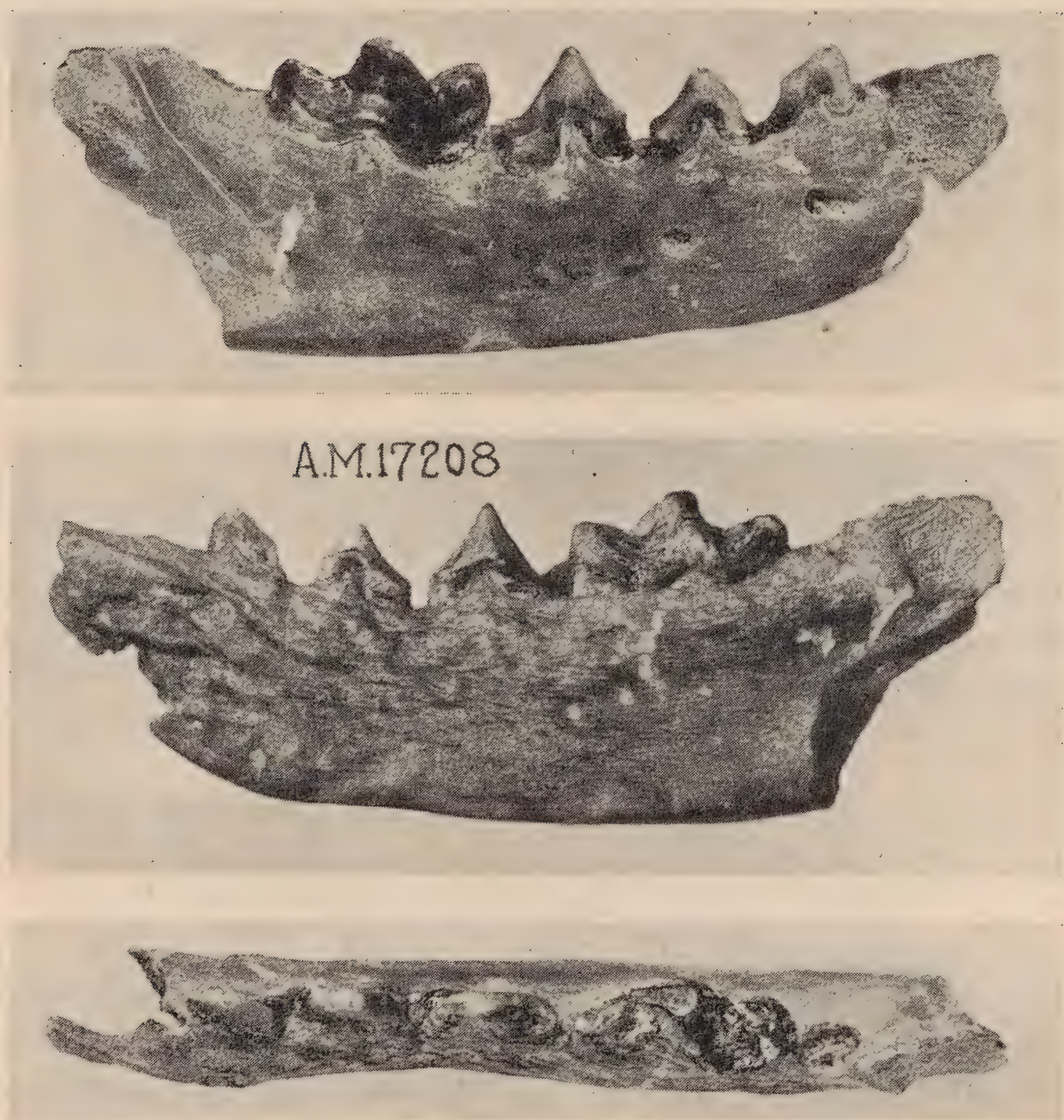


Fig. 35. *Plionictis parviloba*; lower jaw, twice natural size, external, internal and superior views. No. 17208, Snake Creek beds, *M. paniensis* zone.

***Mionictis incertus*, new genus and species**

TYPE.—No. 18263, lower jaw with $c-m_1$ and root of m_2 from lower horizon of Snake Creek, Quarry A, Expedition of 1921.

GENERIC DIAGNOSIS.—Dentition $\overline{?1.3.2}$. Premolars robust with sharp posterior crests but no accessory or heel cusps, apices well forward, especially on p_2 (as in *Lutra*), carnassial stout, trigonid low but somewhat larger than talonid, metaconid strong with posterior crest extending downward and backward, continuous with internal and posterior marginal crest of talonid. Hypoconid external, crested, a small cusp at back of protoconid and directly in front of hypoconid. M_2 with double or semi-double root, crown unknown.

SPECIFIC CHARACTERS.—Size larger, $c-m_2=41.5$, $p_2-m_2=34.5$, carnassial = 12.3. Premolars more robust, shear of carnassial more transverse than in the following species, m_2 with semi-double root.

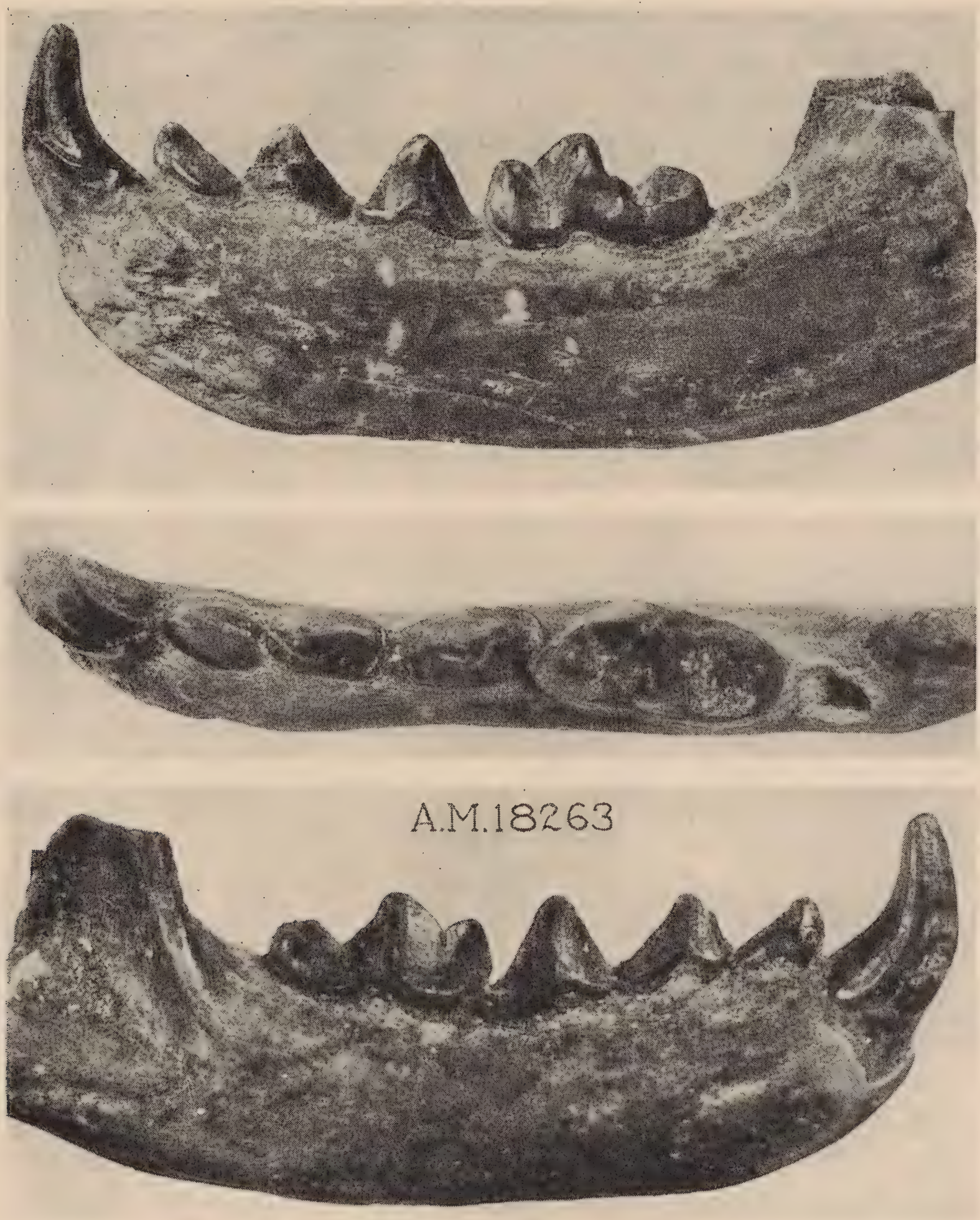


Fig. 36. *Mionictis incertus*; lower jaw, twice natural size, internal, superior and external views. Type specimen, No. 18263, Snake Creek beds, *M. paniensis* zone.

***Mionictis elegans*, new species**

TYPE.—No. 18267, lower jaw with p_2 - m_1 and alveoli of m_2 , p_2 and part of canine alveolus; from lower horizon of Snake Creek beds, Quarry B, Expedition of 1921.

SPECIFIC CHARACTERS.—Size smaller, p_2 - m_2 = 31.0, carnassial = 11.0. Premolars more compressed, shear of carnassial more anteroposterior, m_2 with two separate roots.

LEPTARCTUS Leidy

In 1856¹ Leidy described under the name of *Leptarctus primus* a tooth obtained by Doctor Hayden from the upper Tertiary at Bijou Hills, Mo. The tooth was found along with the type of *Merychippus insignis* and other specimens that indicate its probable age as Upper Miocene. Leidy referred it to the Ursidæ (probably including the Procyonidæ in this family), and compared it to the coati, which he seemed to regard as its nearest living relative. It has been generally considered as a procyonid. In 1894 Doctor Wortman described a lower jaw with canine, p₃ and p₄ preserved, which he referred to *L. primus*²; it appeared to confirm the reference of *Leptarctus* to this family, as the premolars had the characteristic double main cusp of the Procyonidæ. Wortman concluded that the affinities of the genus lay between *Cercoleptes* and the more typical Procyonidæ. In 1899 Matthew³ described a nearly complete carnivore skeleton from the Lower Miocene of Colorado under the name of *Phlaocyon leucosteus* as an intermediate between the primitive Canids (*Cynodictis*, etc.) and the raccoons; it showed a less developed stage of the characteristic upper and lower carnassials of the Procyonids and was intermediate in most other features of the skull and skeleton. It was regarded as an early stage in the evolution of the Procyonidæ, and the very incompletely known *Leptarctus* was assumed to be a later and more typically procyonid genus.

The procyonid affinities of both these genera have been challenged by Ameghino and von Ihering.⁴ So far as I have been able to find, Ameghino never adduced any reasons or evidence for his assertions. Von Ihering states that "Matthew was led into error as regards *Phlaocyon* because he supposed *Bassariscus* to be a Procyonid, whereas it is in truth a Canid." On this point I shall merely observe that several authorities on modern systematic zoölogy⁵ who have in recent years revised and discussed the genera of Procyonidæ, have regarded *Bassariscus* as related to the raccoons, although with undoubted points of resemblance to the Canidæ; that the position assigned to *Phlaocyon* is based upon a multitude of characters in all parts of the skeleton; and that Doctor von Ihering's objections relate only to a single feature of the dentition and his interpretation of this feature would carry as a necessary corollary

¹Leidy, 1856, Proc. Acad. Nat. Sci., Phila., p. 311; 1869, Journ. Acad. Nat. Sci. Phila., (2) VII, p. 70, Pl. I, figs. 15, 16.

²Wortman, 1894, Bull. Amer. Mus. Nat. Hist., VI, p. 229.

³Bull. Amer. Mus. Nat. Hist., XII, p. 54; idem, p. 131, Fig. 10.

⁴Von Ihering, 1910, Archiv f. Naturges., 76 Jg., I, p. 160.

⁵Elliott, 1904, 'Mammals of Mid. Amer.,' Field Col. Mus. Publ., No. 95, IV, part 2, p. 482; Hollister, 1915, Proc. U. S. Nat. Mus., XLIX, pp. 143-150, Pls. xxxviii, xxxix; Schufeldt, 1915, Science, XLI, p. 691; also Beddard, Pocock and others, but I have not the references at hand.

that the Procyonidæ had nothing to do with the remainder of the Carnivora but were of wholly independent origin. Until some more serious objections are raised, it is hardly worth while to reconsider the affinities of *Phlaocyon*.¹

As regards *Leptarctus*, von Ihering states that in his opinion it is a Mustelid, not a Procyonid.² Apparently this statement is based solely upon an examination of Leidy's figure of the type upper p⁴, which does suggest the corresponding tooth in certain Mustelidæ (some of the Melinæ, e.g. *Taxidea*, *Helictis*, *Meles*). Leidy's description, however, would indicate that the figure is inaccurate, for he specifically states that the posterointernal cusp is stronger than in *Nasua*, whereas it is scarcely visible in the figure; in other points also his description would indicate a much more procyonoid character in all the cusps than is shown in the figure.

As a result of a careful reading of Leidy's description and of comparison of various fragmentary specimens of lower jaws in the American Museum collections referred, like the one described by Wortman, to *Leptarctus*, I had quite confidently regarded this genus as a fairly typical Procyonid.

In the collections secured by Mr. Thomson last summer from the Snake Creek quarry is a finely preserved little carnivore skull which, after a careful comparison, I refer to *Leptarctus*. It proves to be a very remarkable type, characterized primarily by the complete loss of m² and by very prominent lateral temporal crests on the cranium. While it has thus the dental formula of a Mustelid, it agrees with the Procyonines in details of tooth construction, in the basicranial region, etc., but in most of these particulars it agrees equally well with certain mustelid genera, especially of the badger group.

***Leptarctus primus* Leidy, 1856**

Type.—An upper carnassial, p⁴ 1., from the Tertiary of Bijou Hills, Mo., presumably Upper Miocene as it was found in company with *Merychippus*, etc.

Neotypes.—A nearly complete skull, Amer. Mus. No. 18241 and a lower jaw, No. 18270, from the lower horizon of the Snake Creek quarries, found by Albert Thomson, Amer. Mus. Exped., 1921.

¹The real underlying reason for the attempt to exclude *Leptarctus*, *Phlaocyon* and *Bassariscus* from the Procyonidæ, is that the existence of Tertiary ancestors of the family in North America would tend to disprove the palæogeographic hypotheses of these writers.

²Von Ihering, 1910, *loc. cit.*, p. 160.



Fig. 37. *Leptarctus primus*; skull, natural size, top, side and palatal views. No. 18241, Snake Creek beds, *M. paniensis* zone.

AUTHOR'S DESCRIPTION.—“A left superior molar tooth, nearly resembling in size and construction the fourth upper molar of the Coati, of South America.

“As in the latter animal the tooth has a trihedral crown and three fangs holding the same relative position.

“The crown has nearly the same proportions as in the Coati but is rather longer in relation with its other measurements. As in the Coati it is constituted of three tubercles externally and two internally. In the fossil the median outer tubercle or cusp is the largest of the five. The posteroexternal tubercle is proportionately larger than in the Coati. The summits of the median and posteroexternal tubercles are continuous, through a trenchant curved edge. The anteroexternal tubercle is rather less well-developed than in the Coati, and is not conical, but crescentoid, with an acute edge or summit continuous with the bases of the median external and the anterointernal tubercle. The latter is smaller than in the Coati and is rather trihedral than conical, while the posterointernal tubercle is proportionately larger, so that the internal tubercles in the fossil are comparatively small and nearly equal in size, whereas in the Coati the anterointernal tubercle is not only much longer than the one behind but is nearly or quite equal to the median external tubercle.”

Leidy gives the following measurements:

	Lines	mm.
Anteroposterior diameter of crown	$3\frac{1}{2}$	= 7.4
Transverse diameter of crown	3	= 6.3
Length of crown	$2\frac{1}{2}$	= 5.2

REVISED DIAGNOSIS (based upon neotypes).—Dentition $\frac{3 \cdot 1 \cdot 3 \cdot 1}{3 \cdot 1 \cdot 3 \cdot 2}$. The teeth compare most nearly with *Procyon* and *Nasua* in structure, but m^2 and p^1 are absent, p^{2-3} much reduced in size and the entire tooth row very short, more as in the badgers. The molarization is somewhat less advanced than in *Procyon* and somewhat more than in *Nasua*; the details of the cusp construction correspond very closely with these two modern genera and are not in any degree intermediate between them and the other Procyonids. Skull with very short, deep, wide muzzle, elongate cranial region, prominent temporal crests diverging backward to meet the occipital crest at the superior angles of a nearly square occiput. Bullæ oval, simple, convex, the long axes of the ovals converging strongly backward, carotid foramen midway on inner border. Anterior end of bulla fully consolidated with the very low and weak postglenoid process which does not project separately behind it; auditory meatus very short,

as in Canidæ and some Procyonidæ; no approach to the long bony meatus and irregularly flattened bulla of modern Mustelidæ and Ursidæ. Basicranium of moderate width. Zygomata very heavy; postorbital processes on jugal and frontal unusually prominent, partly closing the orbit posteriorly.

Leptarctus primus Leidy

Upper Miocene

Lower dentition, $c-m_2=33$ mm. (No. 18270)

Leptarctus wortmani, new species

Lower Pliocene

Lower dentition, $c-m_2=38$ mm.

Type No. 2575, lower jaw, Valentine beds near Hay Springs, Neb., referred by Wortman to *L. primus*.

The fine preservation and peculiar character of the *Leptarctus* skull from Snake Creek has enabled me to identify a skull and jaws which I collected near Pawnee Buttes in 1901 but have not heretofore been able to identify, owing to the badly damaged teeth. This specimen, No. 8390, has both arches preserved, the top and sides of the skull intact and the lower jaws complete at the back, but fracture and weathering had so damaged the dentition that but little of it is left; sufficient however, when compared with the Snake Creek skull, to show that the teeth were the same. The entire agreement in the top of the skull, the zygomatic arches, and in such other parts as can be compared, leaves no doubt that it is the same species. It adds but little to the characters. The upper and lower canines are preserved and the posterior part of the lower jaw is more complete than in the Snake Creek specimens.

Affinities of *Leptarctus*

Wortman concluded that *Leptarctus* was between *Procyon* and *Bassaricyon* in characters. Von Ihering, as already noted, considers it a Mustelid.

The absence of m^2 is a mustelid character. All procyonid genera have m^2 well developed, although considerably smaller than m^1 . The absence of the first premolar and reduction of the second and third occur in both Mustelidæ and Procyonidæ, as well as in other families of Carnivora. The characters of p^4 are decidedly procyonid, resembling *Procyon* and *Nasua*, to a less degree *Bassaricyon* and *Potos*, least of all *Bassariscus*. Some Mustelidæ have a similar adaptation of p^4 , reduction in size and conversion from a shearing to a chopping and crushing type. But the hypocone posterointernal cusp does not develop in the Mustelidæ save to a limited degree in *Taxidea* and *Helictis*, and still less in *Meles*. There is, however, a certain tendency in *Leptarctus* to obliteration of the notch

between the blades of the upper carnassial, and this, as Wortman has pointed out, is a distinctive mustelid character. It is mentioned in Leidy's description of the type p^4 quoted above. On the other hand, *Leptarctus* has no sign of the characteristic mustelid construction of m^1 ,



Fig. 38. *Leptarctus primus*; lower jaw, enlarged to two diameters, external, internal and superior views. No. 18270, Snake Creek beds, *M. paniensis* zone.

the expansion of the inner half in anteroposterior direction, well developed in the more predaceous genera and indicated in most of the genera with more crushing teeth; but the m^1 has the quadrate type of the Procyonidæ and is in detail very like that of *Procyon*. The complete absence of m^2 is not an individual peculiarity, for it is accompanied by a marked shortening of the skull throughout, in comparison with *Procyon*;

and by the relative reduction of m_2 which, however, has the elongate character of Procyonidæ, unlike the round peg style of most of the bunodont Mustelidæ.

The bulla has no bony meatus, a character of all Canidæ and some Procyonidæ, an inheritance from the Oligocene and early Miocene Cynoids, all of which have swollen bullæ without bony meatus; it is also found in *Bunælorus* and some other primitive Mustelidæ. Its peculiar relations to the postglenoid process are unique, so far as I can find, but the position of the bulla in Canidæ and Procyonidæ is further forward than in Æluroids, and the bulla less reduced than in most Mustelids and Ursids, a condition which brings the Canid-Procyonid group nearest to the extreme anterior extension of the bulla seen in *Leptarctus*. The temporal crests are more or less indicated in all the Procyonid genera, but never so prominent as in *Leptarctus*. Similar crests are developed in a few Mustelidæ—occasionally in badgers, etc., normally in *Helictis*, *Plesictis* and some other Tertiary genera. They are developed in a few other Carnivora but never that I have seen to the prominence attained in *Leptarctus*.

It appears on the whole that *Leptarctus* is related both to the Melinæ and to the Procyoninæ, but very aberrant in certain characters (lack of m^2 , prominent temporal crests, peculiar bullæ) which exclude it from anything like the direct ancestry of any of the later genera. The massive zygomata resemble *Phlaocyon* much more than any modern genus of Procyonidæ or Mustelidæ. *Leptarctus* has, however, very little of the primitive and intermediate characters of *Phlaocyon*, which is a true link between Procyonidæ and primitive Oligocene Cynoids. It is a fully developed but decidedly aberrant type, representing a distinct intermediate phylum. Whether this phylum should be included in Procyonidæ or in Mustelidæ requires careful consideration.

The proportions of the skull are different from those of any modern carnivore that I have compared with it. The heavy zygomata and strong postorbital processes are most like those of *Proteles*; in *Felis* the zygomata are deeper under the orbits, not as deep behind, and the postorbital process of the jugal is much more developed, while that of the frontal is rather less so. Among the Mustelidæ, *Taxidea* shows some degree of approach in the zygomatic arches, but these are far more slender in other Mustelidæ or Procyonidæ. The extreme shortness of the muzzle is paralleled in several genera among the Mustelidæ, but the shortening of the basicranial region, also more or less marked in both Procyonids and Mustelids and even more extreme in *Felis*, brings about a different

relation of the component parts in all modern genera, none of which show the fusion of the postglenoid process with the anterior face of the tympanic bulla. In all of the modern carnivora the shortening of the basi-cranial region brings the postglenoid process too far external to the swollen portion of the bulla to fuse with it. In part this may be due to the very general tendency for the external portion of the bulla to subside into a bony meatus even though the internal portion be still inflated. In part it may be due to the outward shifting of the squamosal and with it the glenoid articulation, to accommodate the much increased cerebral lobes of modern carnivora. Other mechanical reasons might also be suggested, but to test their validity fully would require a larger number of complete skulls of diverse types of Oligocene and Miocene Carnivora than is at present known. The fact remains that this complete fusion of postglenoid process and tympanic bulla is unique among Carnivora.

The double temporal crests are equally exceptional as compared with modern Carnivora. It is true that similar crests are developed in *Helictis* and other modern genera, but they are by no means so prominent, and for comparison in this respect one must turn to *Plesictis* of the European Oligocene and Miocene. They are certainly no indication of especial relationship to *Plesictis*, for the dentition of this genus is quite normally musteline, with no approach to the procyonid type, such as is seen in *Helictis* and other Melinæ. The crests in *Plesictis* are nearer to the median line, but their position varies considerably in different species of the genus. In *Helictis* the position and character of the temporal crests is not unlike those of *Leptarctus*, except that they are much weaker and more widely separated, owing to the relatively larger braincase.

The dentition is that of the Mustelidæ but the construction of the teeth is closer on the whole to *Procyon* and *Nasua*. The construction of p^4 is approached by several of the Melinæ, most nearly by *Taxidea*; but the molar of *Taxidea* is widely different. Again, the form and construction of m^1 is approached by *Mephitis*; but p^4 in *Mephitis* is widely different. The bicuspid p_4 and the anterointernal cusp of p^4 are found in all Procyonidæ and in some but not all of the Melinæ. The bicuspid p_3 is unique. The reduction of the premolars is characteristic of the majority of the Mustelidæ and some Procyonidæ (p_1^1 lost in *Cercoleptes*, p_1 in *Procyon*). The loss of m^2 and reduction of m_2 is characteristic of nearly all Mustelidæ, unapproached in Procyonidæ; but in the majority of the Mustelidæ m^1 is much reduced in anteroposterior diameter; less frequently it is also reduced in transverse diameter so as to be quite a

small tooth. Most later Tertiary and modern Mustelidæ show a widening of the inner half of m^1 which is very characteristic and peculiar to the family; but it does not occur in any Oligocene genera and is quite rudimentary in the earlier Miocene genera; hence its absence in *Leptarctus* would not argue against derivation of that genus from Oligocene mustelid ancestry. Another mustelid tooth characteristic is the tendency to union of the two crests of the carnassials, p^4 and m_1 into a single crest by obliteration of the deep notch that separates them in other Carnivora. The Procyonidæ show no trace of this; but a tendency towards it in *Leptarctus* was observed by Leidy in the type tooth and is seen in p^4 of our skull.

The above data appear to show affinities on the one hand to the Procyonine group of the Procyonidæ, on the other hand to the Meline group of the Mustelidæ, with some specializations distinct from either. They are open to somewhat varying interpretation as to the exact phyletic relationship but it will hardly be questioned that *Leptarctus* represents a distinct phylum intermediate between the typical raccoons and the badgers. Whether its affinities are closer to the Procyonidæ or to the Mustelidæ is not easily decided. Both families include a number of distinct phyla, whose precise relations to the Oligocene ancestral stocks are not yet wholly cleared up. One school of taxonomists is apt to solve all such problems by assigning separate family rank to such genera, representing evidently distinct phyla. Thus in the Procyonidæ, *Ælurus*, *Cercoleptes* and *Bassariscus* have each been placed (by different authors) in separate families; and a similar treatment of the Mustelidæ or Viverridæ would result in splitting them up into at least a dozen distinct families (not all of them recognized by any one author). This procedure appears unnecessary and objectionable. To create new families for each of the minor groups into which the Carnivora are divisible merely serves to obscure the broader affinities which the families were intended to represent. The smaller groups may be well enough distinguished as subfamilies or as phyla without whittling down the scope of the families of current usage.

As the absence of m^2 is a specific and formal distinction between Mustelidæ (typical) and Procyonidæ, I refer *Leptarctus* to the former family.

FELIDÆ

True cats and machærodonts occur in the Snake Creek faunas but are rare. In the upper beds a large machærodont has been identified from a lower jaw and a few fragments. Three lower jaws of *Pseudælurus*,

a cat somewhat smaller than a puma, have been secured from the Lower Snake Creek. No Felidæ have as yet been positively identified from the Sheep Creek beds.

PSEUDÆLURUS

Two lower jaws in the American Museum and one in the Princeton collection are referred to this genus. They agree rather nearly with Leidy's type of *P. intrepidus*, save for minor differences of perhaps subspecific rank. All are from the lower Snake Creek beds in Sinclair draw.

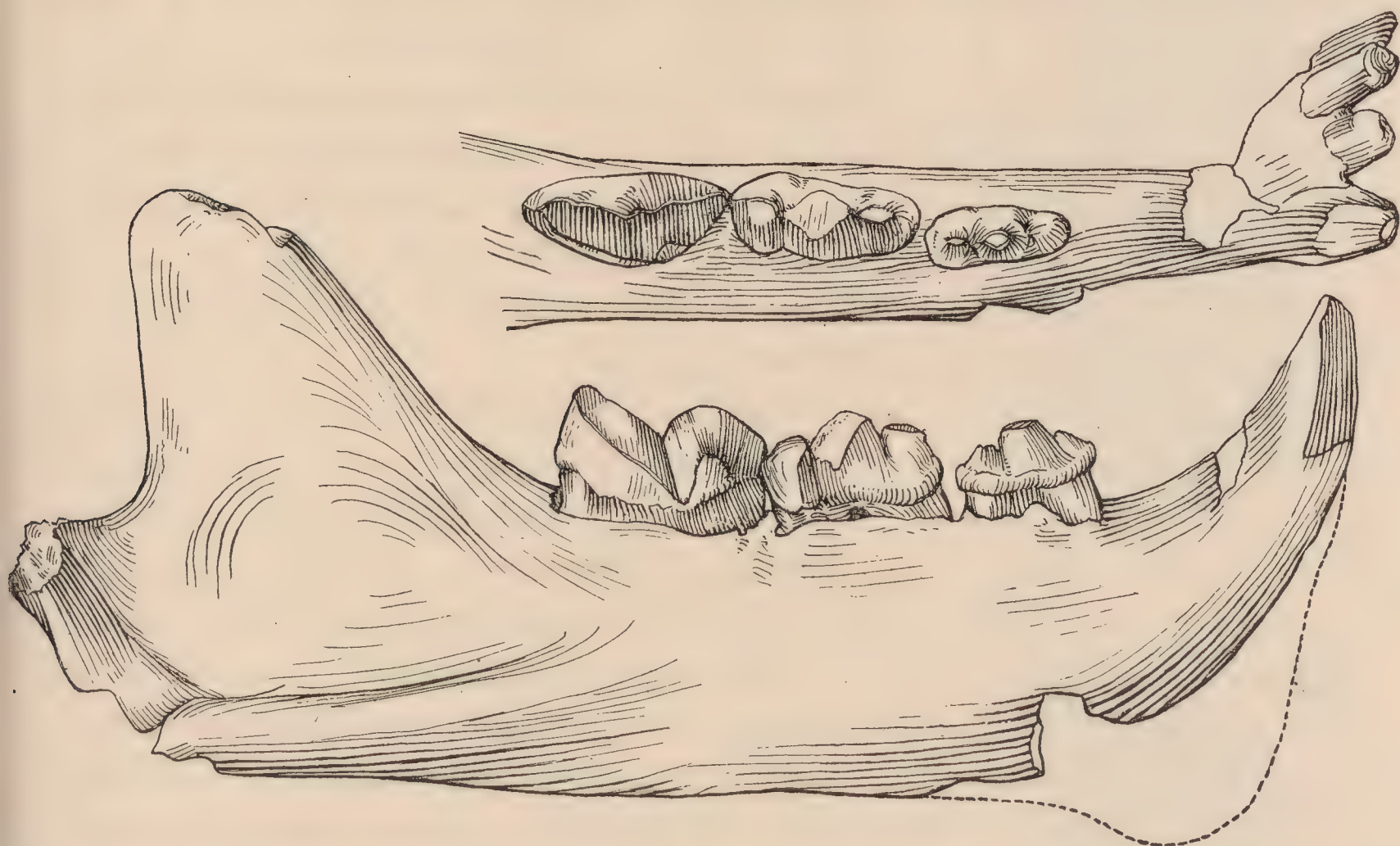


Fig. 39. *Heterofelis catocopis*; lower jaw, one-half natural size, outer view and crown view of teeth. No. 18920, Upper Snake Creek beds, *Aphelops* draw.

Machærodon (*Heterofelis*)¹ *catocopis* Cope

No. 18920, a right lower jaw with complete dentition is referred to this species. The type, No. 8310, Cope Coll., is from the Republican River beds of Phillips Co., Kansas. It is the symphysial portion of a lower jaw, showing the character of symphysis and flange but nothing of the postcanine teeth.

The type of *Machærodon* is *Ursus cultridens* Cuvier from the Val d'Arno Pliocene. The genus is principally known, however, from the species *M. megantereon* of the Perrier Pliocene, which seems to be iden-

¹Cook, Harold J., 1922, Proc. Col. Mus. Nat. Hist., IV, No. 2, p. 7. Type: *M. (H.) coloradensis*, new species, from Lower Pliocene of Colorado, probably a synonym of *M. catocopis*.

tical with *M. nestianus* of the Val d'Arno and with the fine machærodont skull and skeletal material recently secured by Stehlin from the Pliocene of Senèze. It does not appear to differ much from *M. cultridens* but I have failed to find record of any really good topotypes of Cuvier's species. The Perrier species is the type of the genus *Meganterion* Croizet and Jobert, which, although proposed only provisionally, antedates *Machærodus* Kaup 1833 by five years.

The lower jaw here described I take to be the same species as the palate and jaws recently described by Mr. Cook under the name of *Machærodus* (*Heterofelis*) *coloradensis*, from the Lower Pliocene of Yuma County, Colorado. As compared with *M. megantereon* this would appear to be subgenerically or generically distinct, the entire absence of flange leaving only an angulation in the lower jaw, as in *Ælurogale*, the larger size of p_3 , but little smaller than p_4 , also resembling that genus, while in the absence of p_2 and m_2 , talonid of m_1 almost or entirely absent, and relatively large size of accessory premolar cusps, it resembles the other Pliocene and Pleistocene machærodonts.

"*Heterofelis*" is an unfortunately chosen name, being a hybrid of Latin and Greek. But the genus is very probably valid even among the fifteen or twenty names¹ that have been proposed for the (probably) three or more really valid genera of Pliocene and Pleistocene sabre-tooth cats. I accept it provisionally, awaiting a revision of the European Machærodonts based on the Senèze and other material, for a final settlement as to the proper nomenclature and affinities of the several phyla.

The lower jaw from the Snake Creek is a little larger and more robust than Mr. Cook's specimens. It compares quite closely with them, except that he ascribes to his specimens a vestigial metaconid on the heel of m_1 . According to his statement, however, they are all damaged at that point, so that it is not certain that a metaconid was present. In our specimen, which is undamaged, there is no metaconid.

The Snake Creek jaw also agrees closely in size and characters with the type of *Felis aphanista* Kaup, a supposed synonym of *Machærodus cultridens*. If this agreement be confirmed by topotypes of *aphanista*, it will follow that *Heterofelis* = *Machærodus*, and that this genus is distinct from *Meganterion*.

As to the species name used for the Snake Creek jaw, I cannot find any valid distinction between *M. coloradensis* and *M. catocopis*. The Snake Creek specimen certainly agrees with the former, and presumably

¹*Paramachærodus*, *Heterofelis*, *Smilodontopsis*, *Dinobastis*, *Trucifelis*, *Meganterion*, *Machærodus*, *Steneodon*, *Æluropsis*, *Cultridens*, *Drepanodon*, *Homotherium*, *Hyperfelis*, *Neogæus*, *Smilodon*, ? *Priodontes*, ? *Ormenalurus*, and probably others.

therefore belongs to the latter species, with which it accords in size, characters of canine and incisors, and various correlated characters, although the flange is not preserved.

Part of an upper canine, broad and much compressed, is provisionally referred to *M. catocopis* and it is probable that some of the large carnivore bones from the Upper Snake Creek belong to this animal, but we are not able to distinguish them with certainty from true Felidæ, *Amphicyon* or other Carnivora.

EDENTATA

Megalonyx curvidens, new species

The most characteristic edentate specimen found in the Snake Creek beds is a well-preserved lower molar, No. 17601, probably the last (see Leidy, J. 1855. 'Memoir on the Extinct Sloth Tribe of North America,' *Smithson. Contrib.*, VII, Pl. VI, fig. 10) of the left side, found by Mr. Thomson in 1918 in the upper level (Quarry No. 1). To this species may also belong an incomplete claw found in 1908 and a more complete one in the Princeton collection; also navicular described by Sinclair.

SPECIFIC CHARACTERS.—Smaller than *M. jeffersoni leidyi*, *wheatleyi*, etc., of the Pleistocene and *M. leptostomus* of the Blanco, m_4 of less transverse diameter and distinctly more curved (hence probably shorter). Diameters of m_4 antpost. $15 \times$ trans. 17.8 mm., (Note: m_4 of *M. leptostomus* not known).

The characters indicate a more primitive species more nearly allied to *Eucholæops* of the Patagonian Santa Cruz formation. Its relations to *Sinclairia*¹ are wholly doubtful.

It is generally believed that *Megalonyx* is derived from the South American Tertiary ground-sloths and is an immigrant from the Neotropical region like *Myodon*, although arriving at an earlier date. *Eucholæops* (including *Megalonychotherium* of the Santa Cruz) appears to be an



Fig. 40. *Megalonyx curvidens*; type specimen, natural size, No. 17601, Upper Snake Creek beds.

¹Name given by Ameghino to a supposed megalonychid claw described and figured by Sinclair but not named and supposed to be from the Mascall formation, but perhaps from the overlying Rattlesnake in the John Day basin of Oregon.

approximate or direct ancestor both of *Megalonyx* and of the smaller and less known Antillean genera of the Pleistocene (*Megalocnus*, *Acrotocnus*, etc.). *M. leptostomus* of the later Pliocene (Blanco) is slightly, and *M. curvidens* of the earlier Pliocene (Snake Creek) is distinctly nearer to *Eucholæops*, so far as the fragmentary material shows. *Sinclairia* is known only from the claw and throws no light on the matter. If this claw is really from the Mascall we must conclude that an edentate from South America managed in some way to colonize the northern continent in spite of the barrier which prevented any northern animals from reaching South America.

PERISSODACTYLA

Rhinoceroses are fairly common at all levels in the Snake Creek series and horses are overwhelmingly abundant, constituting eighty to ninety per cent of the material as found. No tapirs have been identified. Chalicotheres are found, although very rare, in the Sheep Creek beds, but not in the Snake Creek.

RHINOCEROTIDÆ

Only one really good skull has been found in the Snake Creek quarries, although many jaws and teeth and skeleton bones are in our collections. This skull belongs to a species nearly related to *Aphelops malacorhinus*. A skull of *Peraceras* was found in beds of probably the same formation several miles to the eastward, and is noticed in an earlier article.¹ In the *M. paniensis* zone occur species close to or identical with the more primitive *Aphelops megalodus* and *Teleoceras medicornutus* of Pawnee Creek. In the *M. primus* zone are found jaws, teeth, a fragmentary skeleton, etc., of a rhinoceros provisionally identified as *A. megalodus*.

***Aphelops malacorhinus mutilus*, new subspecies**

TYPE.—A. M. N. H. No. 17584, a skull from the Snake Creek beds, Quarry No. 1, found by Mrs. Albert Thomson in 1918.

SUBSPECIFIC DIAGNOSIS.—Closely allied to *A. malacorhinus* Cope but distinguished by longer and broader nasals, posterior nares farther back, cranium less elevated above facial portion of skull, and nasals less convex.

The skull compares with the type skull of *A. malacorhinus* from the Republican River beds of Hitchcock County, Nebraska, and with a more complete skull recently discovered by the Denver Museum expedition in Yuma County, Colorado.

¹Matthew, 1918, Bull. Amer. Mus. Nat. Hist., XXXVIII, p. 208.



Fig. 41. *Aphelops mutilus*; skull, side views, one-sixth natural size. No. 17584, Upper Snake Creek beds, *Aphelops* draw.

The Snake Creek skull is of about the same size and, although a little distorted by crushing, is very nearly complete. The nasal bones are moderately long and peculiarly broad and thin, as in *malacorhinus*, approaching *Peraceras superciliosus* in type, but apparently longer and more sharply differentiated from the truncated nasals of *P. troxelli*. The occiput has the same high narrow form as in *A. malacorhinus*, a marked contrast to *Peraceras*; but the peculiar concave forehead of the two *Aphelops* approaches *Peraceras*.



Fig. 42. *Aphelops mutilus*, palatal view of type skull, No. 17584, one-sixth natural size.

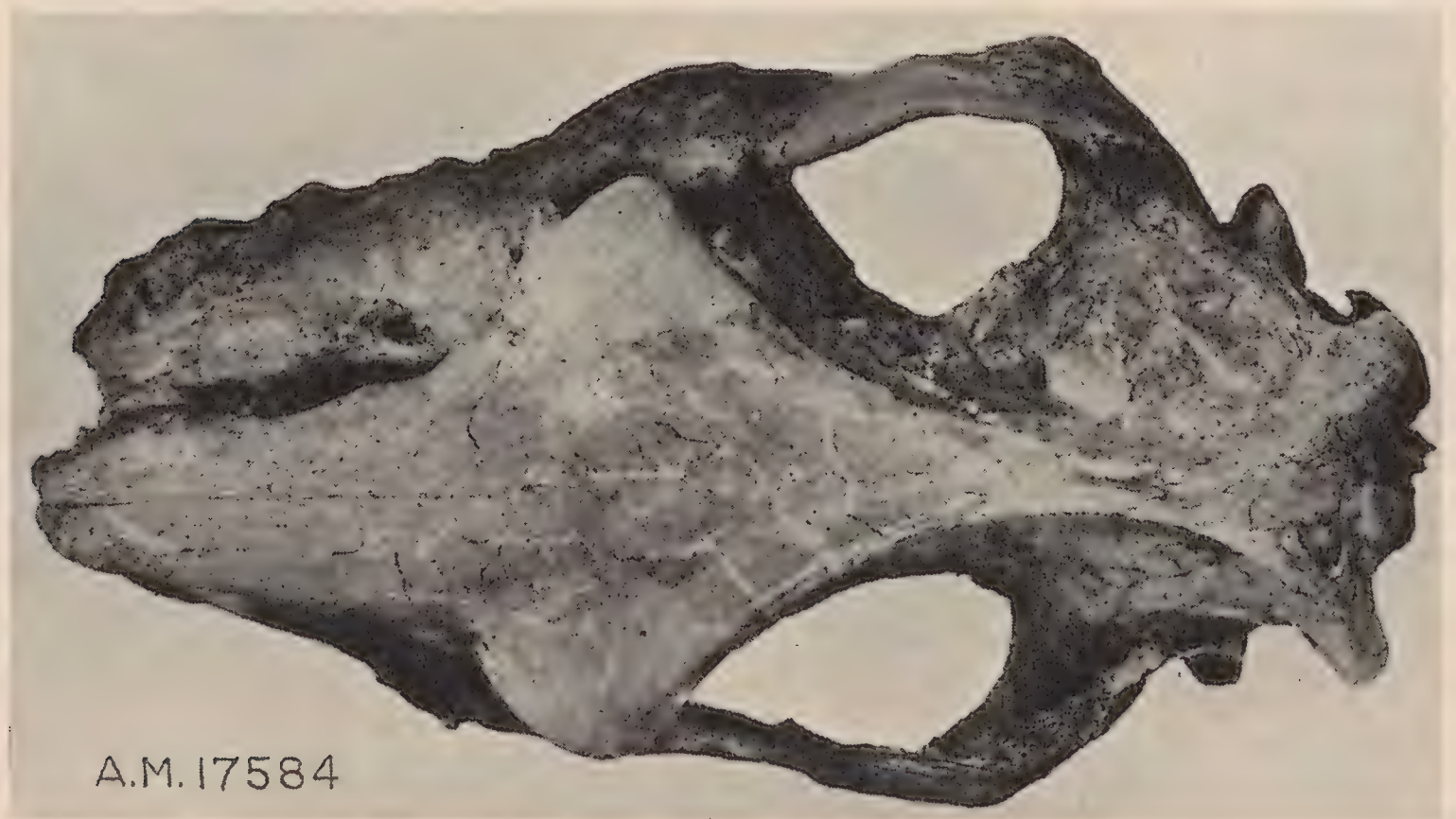


Fig. 43. *Aphelops mutilus*; top view of type skull, one-sixth natural size.

CHALICOTHERIIDÆ

A lower molar and an ungual phalanx serve to prove the existence of a chalicothere in the Lower Sheep Creek beds. It is not *Moropus*; the ungual is shorter and much broader than any of the unguals of *Moropus*. Nor, so far as one may judge from published figures and descriptions, is it referable to *Macrotherium* or *Chalicotherium*. It might be congeneric

with "*Moropus*" *matthewi* Holland, which is nearer to *Macrotherium* than to *Moropus* but very likely distinct from either. Pending the discovery of better specimens I refrain from naming it.

No Chalicotheres have been recognized in the Lower Snake Creek beds, although they occur in the contemporary Pawnee Creek of Colorado ("*M.*" *matthewi*) and Virgin Valley of Nevada ("*M.*" *merriami*). Whether the family survived into the Pliocene in North America is doubtful; an upper jaw figured by Osborn in 1890¹ is supposed to be "Loup Fork" but it may have come from an earlier horizon. It has not been recognized in any of the later collections from known Pliocene horizons.

EQUIDÆ

As a result of the expeditions of 1918–1922 the species of the different horizons are definitely located and distinguished. The great amount of material available for comparison has, however, brought into relief the questionable validity of many of the species of Tertiary Equidæ.

The broad facts of the distribution are as follows.

1.—In the two older horizons (Sheep Creek, Snake Creek A) *Merychippus* is the dominant form, *Parahippus* and *Hypohippus* are scarce. In the upper levels (Snake Creek B and C) *Merychippus* does not occur, save for a few specimens that are suspected of being redeposit from the older channel-beds. *Hipparion*, *Pliohippus* and *Protohippus* (absent in the older zones) are the dominant forms in the order of abundance as listed, *Hypohippus* is rare and *Parahippus* absent.

2.—In the *M. primus* zone the Merychippi are chiefly a small and slender-footed species with primitive teeth and narrow skull. In the *M. paniensis* zone they are chiefly a larger and more progressive form which agrees best with *M. paniensis*.

3.—In the highest beds of the Snake Creek series (Hor. C) the large Pliohippi appear to be relatively common, while *Hipparion* is more prevalent in the lower part of the upper division (*H. affine* zone, Hor. B).

4.—The Equidæ of the upper horizons are chiefly *Pliohippus* and *Hipparion*; there are at least two common species of each genus. "*Protohippus*" *placidus* is scarce and *P. perditus* doubtfully present. *Hypohippus* is very rare (possibly due to redeposit), *Parahippus* is absent and *Merychippus* rare and doubtful, as above noted.

¹Bull. Mus. Comp. Zool., XX, p. 100, Fig. 18.

Validity of Species

It is not the purpose of the present contribution to revise critically the species and genera of American later Tertiary Equidæ, but comparisons with all of them have been necessary for the purpose of identifying the material at hand. This represents many thousands of individuals, no two of them exactly alike in the complex details of tooth construction. If the standards of species distinction that have been accepted by most American students of fossil Equidæ were applied conscientiously to this great collection, the result would be to place upon record scores if not hundreds of "new species" from this one locality. But the thousands of isolated teeth or other fragmentary specimens would clearly show that there are no really constant and uniformly associated distinctions between such "species." They are merely individual differences and it is the scanty or fragmentary character of the material or a failure to make a thorough and impartial study of all materials available for comparison, the natural tendency to compare only the types or best preserved specimens, or to use drawings in place of the originals, that have been responsible for maintaining many of these species as distinct.

It is, of course, quite probable that equally abundant material from many localities would show that the average or typical character of these closely allied "species" differed in much the same way as the geographical variants among modern mammals that it is now customary to describe as "new species." But it is only very rarely that the palæontologist has enough material really to establish such species and the proposal of them is almost always to be regarded rather as a tentative claim than a proof of their existence. Unfortunately such claims serve as the foundation for elaborate superstructures of hypotheses of geographic distribution and migration, whose tenuous and doubtful foundation is not in the least appreciated by the ambitious builders. It would serve far more for the advancement of real and permanent knowledge of fossil vertebrates to adopt a more conservative attitude in this, as in some other matters, and so far as the Snake Creek fauna is concerned, that is the present writer's aim.

Parahippus integer, new species

TYPE.—H. C. 310, upper jaws in collection of Harold J. Cook.

PARATYPES.—A. M. N. H. Nos. 17567, 17568, lower jaws.

CHARACTERS.—This is a species of medium size in the genus, rather brachyodont, but with the crochet well developed. Comparison with the type of the genus *P. cognatus* can be made only by inference, as the milk dentition of the present species has not been recognized in the Snake Creek collections and as Gidley has stated the type of *P. cognatus* consists of milk teeth.



Fig. 44. *Parahippus* near *cognatus*; skull and jaws, one-half natural size. No. 14305. Miocene, near Marsland, Nebraska.

The milk and permanent dentitions of this genus are, however, positively associated in the small and primitive species *P. pristinus*, Lower Rosebud, and in an undescribed *Parahippus* skull and jaws, No. 14305, from the Miocene near Marsland, Nebraska. The *P. pristinus* has very brachyodont milk teeth with simple construction, much like those of *Mesohippus* and far more primitive than the *P. cognatus* teeth. In No. 14305 the milk teeth are quite near to those of *P. cognatus*, although not so progressive in the *Merychippus* direction, while the permanent molars are of the long-crowned, progressive type seen in *P. coloradensis* but distinctly further advanced towards *Merychippus*. It is to be presumed therefore,

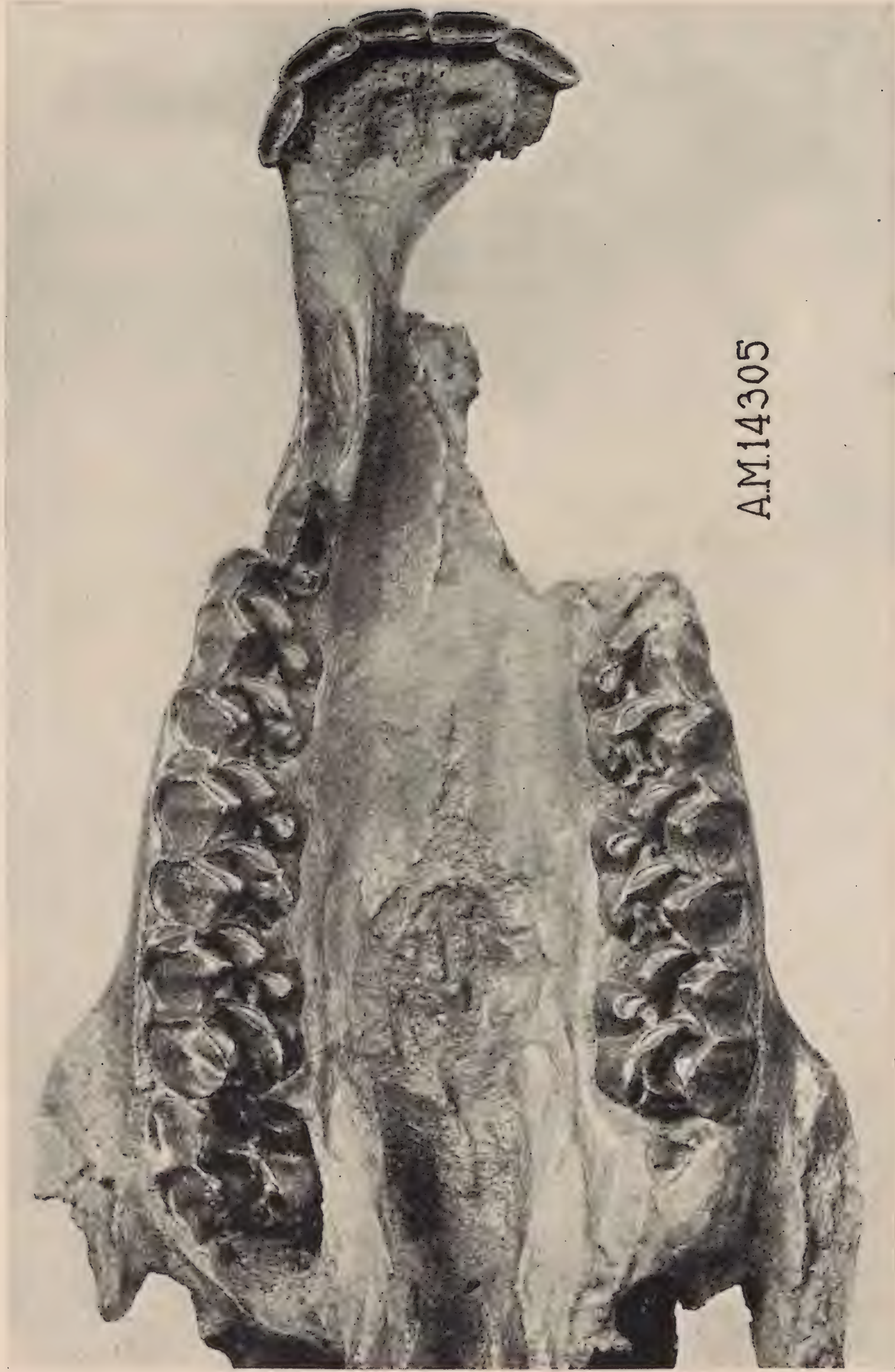


Fig. 45. *Parahippus near cognatus*; upper teeth of No. 14305, showing the milk premolars with the permanent incisors and first premolar and first molar of right side.

à fortiori, that the permanent dentition of *P. cognatus* was of very progressive type, somewhat more so than in the Marsland specimen and decidedly more so than in any described species of the genus. *P. brevidens* would perhaps make the nearest approach, but although long-crowned and heavily cemented, the pattern of this species does not show the marked approach to that of *Merychippus* that must inferentially have been shown by the permanent teeth of *P. cognatus*. It may be that some of the materials from Snake Creek and other equivalent horizons, that have been regarded as primitive species of *Merychippus*, are really the permanent dentition of *P. cognatus* or closely allied species.

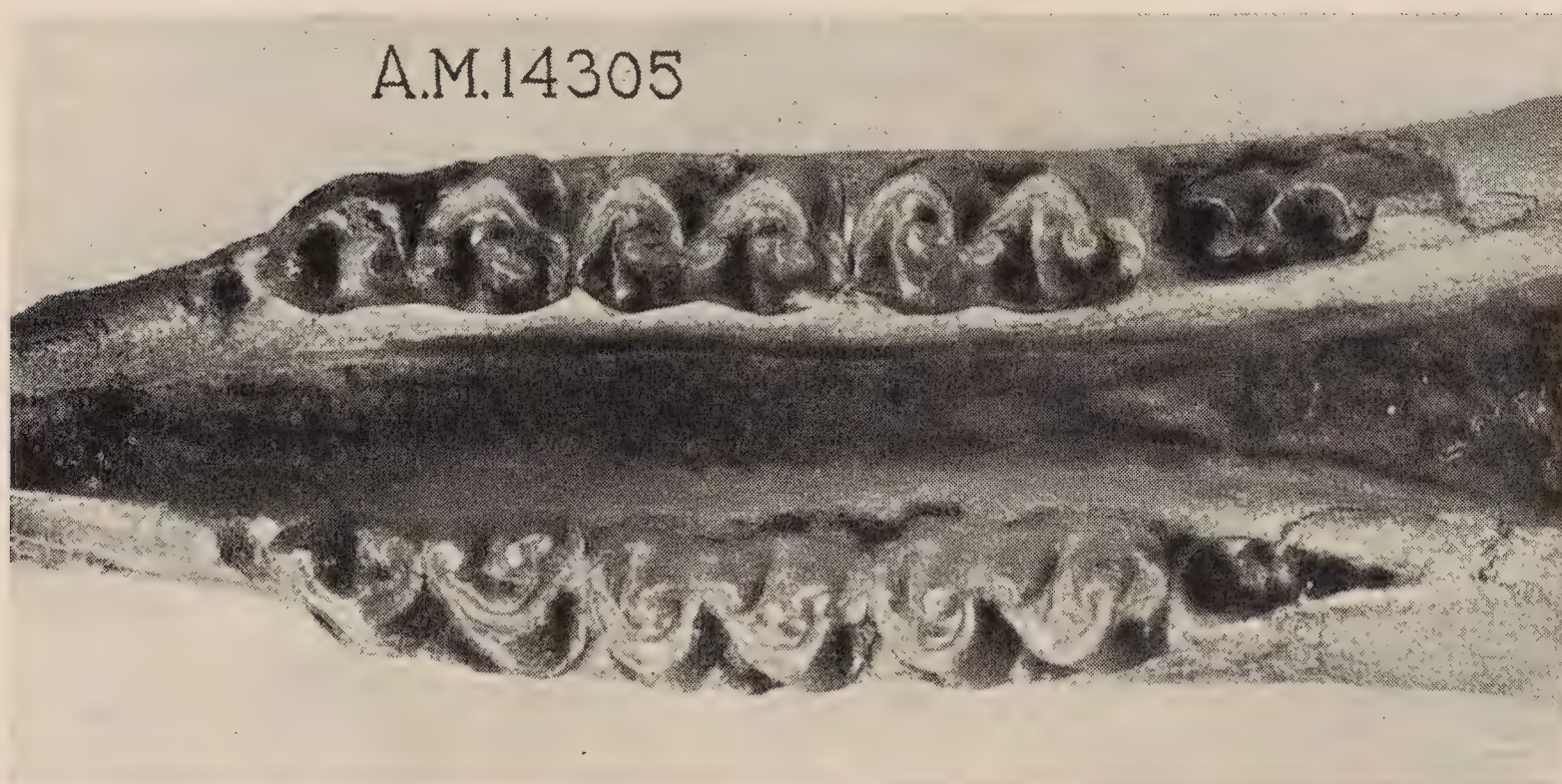


Fig. 46. *Parahippus* near *cognatus*; lower teeth No. of 14305, showing the milk premolars and first molar partly emerged.

On the other hand, *Parahippus integer* belongs to what has been usually regarded as "typical" *Parahippus* but is really better represented by *Anchippus* Leidy and *Desmatippus* of Scott. It is sharply distinct from *Merychippus*, about equivalent to *Hypohippus* or *Anchitherium* in progressiveness, but with the transverse crests less continuous, a small crochet, rugose enamel, metastylid and metaconid well separated. The feet are not known; presumably, as in other species of *Parahippus*, they are Protohippine, whereas in *Hypohippus* they are Anchitheriine. *Hypohippus pertinax* of the Snake Creek fauna is of nearly the same size as *P. integer*, and looks much like it superficially; but they are not in fact closely related, as the comparison of complete skulls (were they known) or feet would demonstrate.

It is not far removed from *P.* (*Archæohippus*) *mourningi* of the Barstow Miocene of California¹ but the crochet is more developed and the parastyloid more separated.

***Archæohippus penultimus*, new species**

TYPE.—No. 18950, fragment of lower jaw with p_3 - m_1 .

PARATYPE.—No. 18951, isolated lower molar. Both from Sheep Creek beds of Stonehouse draw quarry.

CHARACTERS.—Size of *Mesohippus bairdii* but with much higher crown. Construction of lower teeth nearly as in *Parahippus* but metaconid and metastyloid separated only at extreme tip, as in *Hypohippus*. No external or internal cingula; molar slightly narrower than premolars. Enamel obscurely rugose.

MEASUREMENTS

	No. 18950, type	No. 18951
Length, p_4 - m_2	31.8	
P_3 , diameters, a.-p. $\times$ tr.	10.1 $\times$ 9.0	
P_4 , " " "	10.7 $\times$ 9.2	12.6 $\times$ 8.8
M_1 , " " "	10.2 $\times$ 8.1	
Depth of jaw beneath m_1	23	

AFFINITIES.—The reference of this species to *Archæohippus* is provisional in absence of the upper teeth. Except for the type and paratype no specimens from the Sheep Creek beds have been recognized as referable to it. It has not been found in the Snake Creek beds; but a specimen from the Pawnee Creek beds, No. 6305, a lower jaw fragment with m_3 , is tentatively referred by Gidley and myself to this genus. The Pawnee Creek specimen accords in size with *A. ultimus* of the Mascall but is not directly comparable; in the m_3 the relatively smooth enamel and absence of metastyloid agree with *Hypohippus*, but the crown is much higher and the third lobe large, as in *Parahippus*. This is the construction that one would expect to find in *Archæohippus* from the characters of the upper molars. A metapodial, No. 8799 from the Martin Cañon beds of the same locality, may also belong to *Archæohippus*. It is about the size of *Mesohippus bairdii* metapodials but shorter, heavier and more compact, with a distinct though narrow facet, facing proximad, for the inner cuneiform. In these and some other particulars it approaches *Hypohippus* and *Anchitherium* and differs from *Mesohippus*, *Miohippus*, *Parahippus* or *Merychippus*.

Parahippus mourningi of the Barstow is apparent close to *Archæohippus*, as pointed out by Doctor Merriam, and has been definitely referred by Osborn to the genus.

¹Merriam, J. C., 1919, *loc. cit.*

The geologic range of the phylum, if these references are correct, is from Lower to Upper Miocene as follows:

Barstow, Cal. *A. mourningi*, parts of upper and lower jaws.

Pawnee Creek, Col. *A. sp.*, part of lower jaw.

Snake Creek, Neb. Not found.

Mascall, Ore. *A. ultimus*, part of skull, teeth.

Sheep Creek, Neb. *A. penultimus*, part of lower jaw.

Martin Cañon, Col. *A. sp.*, metatarsal.

***Merychippus paniensis* Cope**

To this species I refer the great bulk, about ninety to ninety-five per cent, of the Equidæ from the Lower Snake Creek. The *Parahippus* and *Hypohippus* material constitutes perhaps two per cent, the remainder consists of *Merychippus* specimens of doubtful reference, differing so much from the usual type that they must represent either distinct species or abnormal variants of the common form.

Within the material that I have referred to *M. paniensis* there is a wide range of variation, in size, length of crown and other proportional characters, in the degree of union of the protocone, the development of hypostyle, thickness of external styles, complication of the enamel on the lake borders, etc. Where these characters are associated with differences in geologic or geographic position it is advisable to distinguish them as varieties or mutants. In the Snake Creek material they are all found in a few small pockets and probably lived at the same time and place. It is to be concluded that the species was a variable one. Some specimens are as large and progressive as *M. calamarius*, others as small and primitive as *M. severus*. Among the scarcer variants are a few doubtfully referred to *M. eohipparion*, *M. proparvalus*, *M. sphenodus* and *M. sejunctus*, and a few very primitive, small, short-crowned, the crescents incomplete and the milk dentition practically inseparable from *Parahippus cognatus*, perhaps referable to that species or to *M. brevidens*. Nor is it always easy to draw the line between *Merychippus* and *Protohippus* in the permanent teeth; but in all the collections that are known to be from the older pockets there is no milk molar of the *Protohippus* type. All are broad and low-crowned, though often heavily cemented at a certain stage of wear.

From the great variability of the Snake Creek *Merychippus* the inference might be drawn that the number of species of this genus recognized by Osborn should be very greatly reduced. This may be so, but the proof is wanting. Most of the described species are based upon a single or a very few specimens. The Pawnee Creek Colorado collections

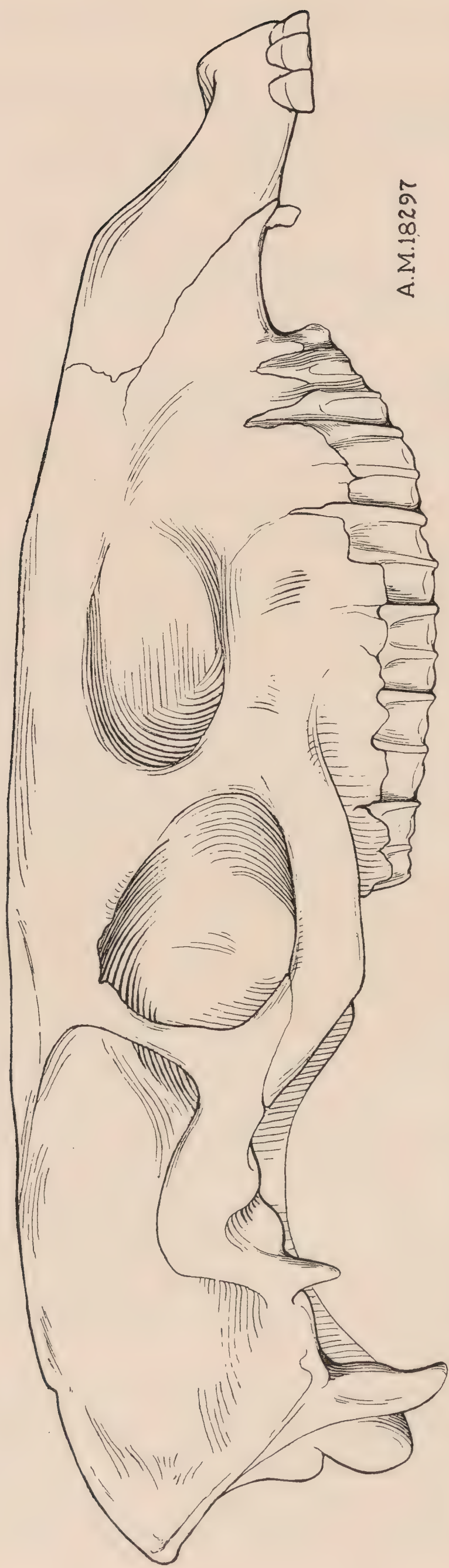


Fig. 47. *Merychippus paniensis*; skull, half natural size. No. 18297, the muzzle completed from No. 18299. Snake Creek beds, *M. paniensis* zone.

Typical adult skull of the most abundant and characteristic animal of this faunal zone.

and those from the Barstow Miocene of California are the only ones at all comparable to those from the Snake Creek and Sheep Creek locality. The former include a good series of skulls and partial skeletons and, while Professor Osborn has made but little mention of these referred specimens, they appear to fall into a number of closely allied species or subspecies rather than a single widely varying one. The distinctions in the teeth are at least partially confirmed by more marked differences in



Fig. 48. *Merychippus paniensis* (above) and *M. primus* (below). Skulls, side view, one-third natural size.

skull and feet. As to the "Sheep Creek" *Merychippi* they show a progressive change corresponding to their stratigraphic position that is supported by far too much material to be accidental.

The Barstow collections are more fragmentary and, although less abundant, the material presents a very similar problem to that seen in the Snake Creek *Merychippi*. Dr. Merriam has solved it somewhat differently, recognizing three supposedly distinct species, and in the earlier studies on the Snake Creek *Merychippi* I was disposed to recognize at least two distinct species and three or four more as doubtful.

Additional material, however, shows the variability of many of the characters at first thought distinctive and (contrary to Dr. Merriam's expectation in such cases) it has NOT enabled me to find new distinctions of a more constant kind to take their place.

FACIAL FOSSÆ.—The fossæ in *Merychippus* vary widely with age and apparently the individual or sex differences are great; nevertheless, some differences appear to be specific. In the *Pliohippoid* group the lacrymal and malar fossæ are both deep and extensive; in the *paniensis* group the lacrymal is deep, the malar absent; in the *sejunctus* (Protohippoid) group both fossæ are shallow. Ontogenetic changes appear to result in filling of the malar and contraction of the lacrymal, the filling being partly due to shallowing of the bottom of the pocket, partly to contraction of its margin, and by no means constant in its course or uniform in its effects. The adult skulls of *M. isonesus*, however, still show an extensive although rather shallow fossa, chiefly in the lacrymal fossa area. The deep, restricted, sharply outlined lacrymal fossa of *M. paniensis* and *sphenodus*, the obscure shallow fossæ of *M. sejunctus* and *republicanus*, etc., are probably valid specific characters; at all events, they are not age variations.

It should be observed, however, that the distinction of *Pliohippus* from *Protohippus* or *Hipparion* by the facial fossæ cannot be maintained, as the malar fossa disappears in adult *Pliohippus*, in some species at least.

***Merychippus insignis primus* (Osborn)**

Merychippus isonesus primus Osborn, 1918. Mem. Amer. Mus. Nat. Hist., II, part 1, pp. 102–104, Fig. 78; Pls. 13.3, 14.2, 14.4. XIII, fig. 3, XIV, figs. 2 and 4.

Type: a series of upper teeth, No. 14187, Lower Sheep Creek beds, Olcott Hill.

Neotype: No. 18944, a nearly complete skull, Lower Sheep Creek beds, Stonehouse draw. See Figs. 48, 55.

Topotypes: numerous skulls, palates, jaws, limb and foot bones from the same quarry as the neotype.

The type was provisionally placed as a subspecies of *M. isonesus*, the milk dentition and the skull being then unknown. The series obtained in 1922 shows every stage in age and defines the limit of individual variation exhibited by the animals that then frequented that locality. About two hundred upper milk dentitions are at hand for comparison and it is impossible to find in them any constant distinctions from the type of *M. insignis* from Bijou Hills, Missouri. Whether this species in

turn is distinct from the type of *Hippodon speciosus*¹ from the same locality may be questioned; but a number of upper teeth from Bijou Hills, referred to *H. speciosus* by Leidy, are pretty certainly distinct from the present species. Until adequate series of topotypes are obtained at Bijou Hills, the species described by Leidy from that locality cannot be fully validated.

The range in size among the teeth is considerable; some specimens are as large as Leidy's type of *M. insignis* or even somewhat larger; the great majority are distinctly smaller. All of them show a rather close approach in pattern to the type and are distinguished by relatively primitive pattern, the ancestral transverse lophs being unusually distinct, the median valley between them comparatively open, the enamel-folds rather simple and inconspicuous, disappearing in well-worn teeth. In all structural details the teeth approach *Parahippus*.

ONTOGENETIC STAGES IN *M. primus*.—The very large series of jaws, juvenile and adult, from the Stonehouse draw quarry fall quite exactly into six definite stages in the growth of the teeth.

1.—Milk premolars fully emerged but unworn; no permanent teeth have broken through the jaw.

2.—Milk premolars considerably worn; m_1^1 emerged but almost unworn.

3.—Milk molars in course of replacement, dp_{2-3}^{2-3} usually out, dp_4^4 usually still present, the permanent premolars not fully emerged, m_{1-2}^{1-2} emerged and m_1^1 a little worn.

4.—All the permanent teeth in place, m_2^2 unworn and not always fully emerged.

5.—All the permanent teeth moderately worn.

6.—Teeth heavily worn, p_2 sometimes worn to base and lost.

The latter two stages may perhaps be divisible into two additional stages, but there is no mistaking the unity of the first four. There is little variation from the normal; anything like an intermediate is not to be found.

When compared with the modern horse these growth stages correspond, the first to a colt a few days or weeks old, the second to a colt a little over a year old, the third to a colt between two and three years old, the fourth to a four-year-old horse, and so on.

The explanation of these curiously limited growth stages would seem to be as follows:

¹Figured by Leidy in 1869, Journ. Acad. Nat. Sci. Phila., VII, Pl. xix, fig. 23. The original is in the American Museum collections.

a.—The young were all born at about the same time of year, presumably in the early summer.

b.—The trapping and entombment of the animals in these channel-bed formations occurred chiefly or wholly at a definite season of the year, presumably the middle or latter part of the summer season, when the stream was reduced to a string of scattered pools to which the animals resorted to drink and were destroyed by carnivora, caught in quicksands or met with other misadventures, their remains accumulating only during the few weeks of low water, and buried by the floods of the next rainy season.

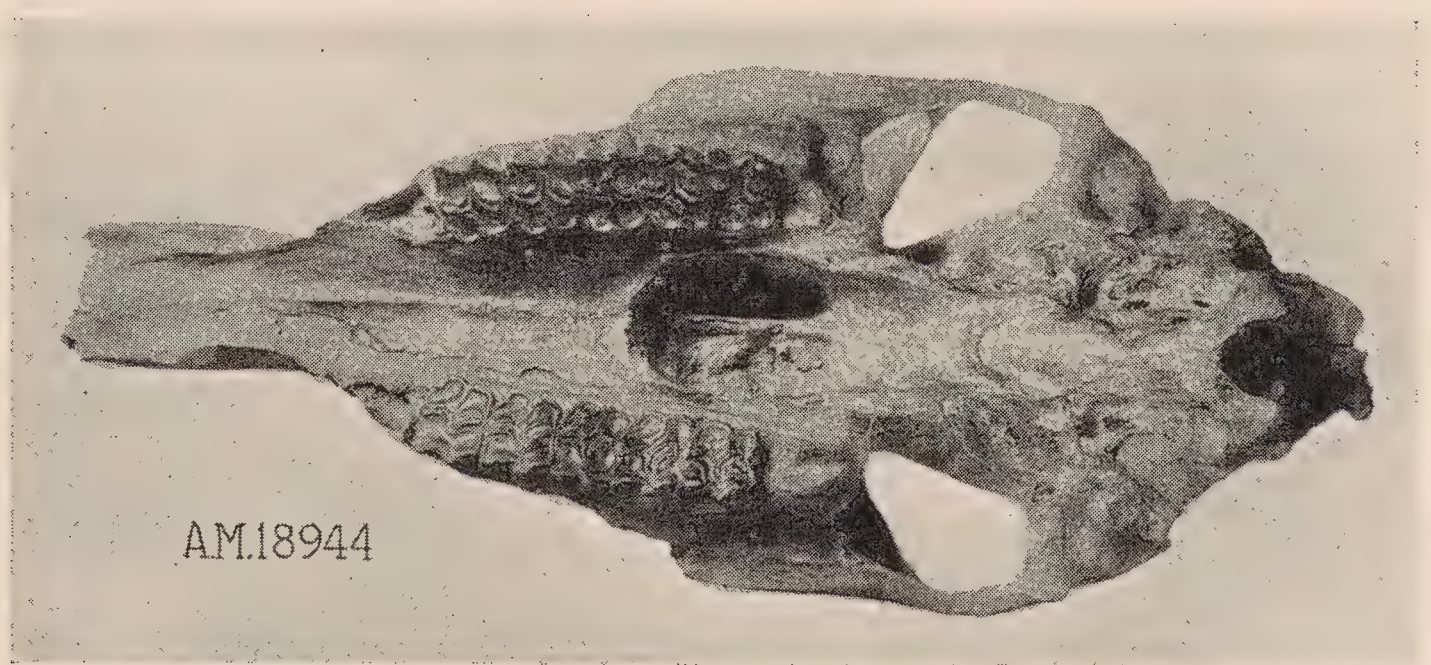


Fig. 49. *Merychippus primus*; adult skull with well-worn teeth. No. 18944, one-third natural size. Sheep Creek beds, *M. primus* zone.

If this interpretation be correct, then our stages are the stages of annual growth of *Merychippus*, beginning with colts a few days or weeks old, then year-old colts, two-year-olds, three-year-olds and so on. The evidence would prove that *Merychippus* developed somewhat more rapidly than the modern horse, a three-year-old *Merychippus* being as fully grown as a four-year-old horse. It would indicate with less certainty that the period of its adult life was relatively short, not over four or five years at most, in contrast to the fifteen or twenty years that a horse ordinarily lives after it is full-grown. The later stages, however, are not so clearly distinct; in adult life the individuals varied in wear, so that the stages approach or even overlap, and could only be separated by finding the nodes in average measurements of a very large series of specimens.

The validity of these conclusions turns upon the soundness of the two stated assumptions, *a* and *b*. The first will hardly be questioned, as

seasonal parturition is generally prevalent among the larger mammals, and among plains-living herbivora the season is usually early summer. The second will be regarded as doubtful or improbable by many—perhaps most—geologists who are obsessed by the traditional text-book idea that fossil remains were animals drowned by rivers during flood, whose remains were washed down by the stream to their present location. There is no doubt that the Snake Creek quarries were chiefly river-channel fillings, and that a large part of the bones have been more or less water-worn; but I think it doubtful whether they have been carried very far, and so large a proportion is wholly unworn that one can hardly assume more than a certain amount of scattering and redeposit at a few feet or yards distance from the original location of the carcass. The scattering and breaking of the bones may be largely due to carnivora or to trampling by other animals, and the accumulation during dry seasons in and around waterholes and pools in streams at the present day is a matter of common observation, whereas I do not know of any recent or verified observations of the accumulation of a large number of carcasses of animals at one point as a result of flood conditions. Animals drowned and carried down by floods would be buried in the midst of such vastly greater quantities of vegetation, mud and sand, that the remains would be fossilized as isolated skeletons in a great mass of sediment and rarely, if ever, in the form of a fossil quarry.

It will be obvious at all events that the definite growth stages in the *Merychippus* material indicate that it was accumulated in the Stonehouse draw quarry during a limited season of the year, and similar stages observed in other quarries indicate that Quarries A and B of 1921 were similarly limited; and the analogies of modern observed conditions conform best with the interpretation here placed upon it. Whether the whole of the fossils in each quarry were accumulated during the dry season of a single year, or represent regularly or occasionally recurrent conditions during a succession of years, I do not know.

Loomis has observed¹ similar growth stages in the large series of *Stenomylus* remains which he described from the "*Stenomylus* quarry" near Agate, Nebraska. He interprets them in a similar manner, save that he ascribes the quarry accumulation to a sudden flood which had drowned a large herd of the animals at one time. An alternative explanation that has been suggested is based upon analogy with the habits of modern guanacos and assumes that the quarry is an old "bedding-

¹Loomis, F. B., 1910, Amer. Jour. Sci., XXIX, p. 303.

ground." In either case, or under other possible explanations, the definite growth stages point probably to a seasonal limitation, within a few weeks at most, and not to continuance of the conditions of deposition through any large part of the year. The fact that they are recognized in two different animals (and apparently are present in others) would eliminate the possibility that they might be due to special susceptibility of *Merychippus* to disease or accident at certain critical periods of its growth.

PLIOHIPPIUS Marsh

The type of the genus is *P. pernix* Marsh, which if not identical with "*Merychippus*" *mirabilis* Leidy, is at least very closely allied to it. This species is unfortunately a marginal one in the genus, hardly distinct from *Merychippus*. The group included under the generic name *Pliohippus* is much better represented by the two fine skeletons that form the types of *P. leidymanus* Osborn and *P. lullianus* Troxell. The first, an adult (?) female, has the lacrymal fossa partly obliterated by crushing of the skull, but probably originally deep and extensive; the malar fossa absent. The second, a young individual, has both malar and lacrymal fossæ wide and deep; it shows the deciduous molars narrow, subhypodont and heavily cemented, clearly distinct from the broad brachydont and imperfectly cemented type of *Merychippus*.

The permanent dentition is distinguished from that of *Merychippus* by large size, greater hypsodonty and heavy external styles. The protocone is united at its anterior end to the protoloph almost to the summit of the crown; the enamel is little or not at all plicated, the protocone is oval or but little flattened, the metaloph is not reduced postero-internally, the teeth are relatively broad, strongly curved, the enamel lakes large. These characters are shared by certain species of *Merychippus* and distinguish *Pliohippus* from *Equus* and *Neohipparion*.¹

It is commonly said that *Pliohippus* is monodactyl, *Hipparion* and *Neohipparion* persistently tridactyl, and that the latter cannot therefore be ancestral to the monodactyl *Equus*. But in fact the lateral digits are

¹The protocone is united in *Equus*, but less broadly, less completely and at a different point. In *Hipparion* proper the protocone is oval; in *Neohipparion* it is flattened in the same manner as in *Equus*. The *Neohipparion* molar is directly converted into that of *Equus* by upgrowth of the bridge between protocone and protoloph; an intermediate stage in this upgrowth is seen in *N. princeps* of the Florida Pleistocene, which is a typical *Neohipparion* near the summit of the crown but when sectioned becomes *Equus fraternus*. Other undescribed specimens of *Neohipparion* are in varying degrees intermediate in this character. The conversion of *Pliohippus* into *Equus* requires more considerable and varied changes, including a partial reversion to the semi-separate protocone. Merriam has, however, described from the Pacific Coast species which, so far as the very imperfect material indicates, appear to bridge the gap between *Pliohippus* and *Equus*. Whether *P. proversus* should be referred to this genus or to *Equus* is a question, just as it is a question whether *N. princeps* properly belongs in *Neohipparion* or in *Equus*.

known only in one species of *Neohipparion*,¹ in which they are very greatly reduced, and it is only the Old World Hipparions that show any indication of persistent tridactyly. And while certain species of *Pliohippus* are apparently monodactyl, it must be remembered that there is at least one large Texan species in which the lateral digits are complete and well developed. Probably in both *Pliohippus* and *Hipparion* some species were tridactyl and others monodactyl.

Relationship to *Equus* and *Hippidium*

The foot-bones which can be positively associated with *Pliohippus* have, however, a much nearer approach to the robust proportions of *Equus* than any which can be positively associated with *Neohipparion*, nor are there any known species of *Neohipparion* save *N. princeps* which approach *Equus* in size anywhere nearly as closely as do the larger *Pliohippi*. I suspect that these two facts are interdependent² and that until or unless large Pliocene species of *Neohipparion* are discovered, the gap between this genus and *Equus* will not be filled. But it is unfortunate that the writers who have insisted upon the relationship of *Pliohippus* to *Equus* have paid no attention to the much closer approach seen in the large monodactyl species of this genus to *Hippidium*, and especially to *Onohippidium*.

Upon the evidence as it stands I should regard *Equus* as directly descended neither from *Pliohippus* nor *Hipparion*, as represented by the typical or better-known species, but from unknown or slightly known Pliocene species intermediate between the two genera, referable to the one or to the other genus, or to *Equus*, according to the generic definitions accepted. I believe, however, that the hard and fast lines of distinction that it is customary among palæontologists (and zoölogists) to draw between "species" are not justified by the evidence; that when one deals with very extensive series of specimens from many closely succeeding stages and many localities, the amount and character of intergrading and mixture of their species characteristics is only explicable as the result of continual admixture of numerous interbreeding strains, so that the "species" is merely a more or less arbitrary selection of material representing approximations to a strain locally and temporarily dominant. It is to be pointed out in this connection that interbreeding

¹*Neohipparion* proper, exclusive of the species with oval protocone.

²The large species of *Hipparion* proper from the Mediterranean and Indian regions show this approach to *Equus* in proportions of skull, foot-bones, etc., but they belong to the group with oval protocones, large lateral digits, etc., not in the line of *Equus* ancestry, although they parallel it in these characters, mainly functions of size.

does not produce exact intergradation in the characters of a series of specimens but various admixtures of more or less distinct and definite characters. The indirect effects of such interbreeding as shown in the fossil record may be far more extensive than one would at first suppose, as I have elsewhere attempted to point out.¹

From this viewpoint the more detailed affinities of the later Equidæ are matters of degree of relationship or dominance of one or another ancestral stock in a complexity of intercrossing strains which only slowly and gradually take on that complete infertility between progressively diverging groups which brings about definite and permanent distinctness.

The South American group of one-toed horses of which *Hippidium*, *Onhippidium*, *Hyperhippidium*, etc., are known to us, appear to be approximate derivatives of the large monodactyl species of *Pliohippus*, but have little if any *Hipparion* blood in them. The various Pliocene and Pleistocene species which are referred to *Equus* are derivable from a group of intermediate more or less interbreeding species which had various proportions of *Hipparion* and *Pliohippus* blood in them, the *Hipparions* being mostly unknown "species" of the *Neohipparion* group, the *Pliohippi* of a group represented by *P. proversus*, so far as our very slight knowledge of that "species" goes. Since *Equus* appears in the later Pliocene of the Old World but only in the Pleistocene of the New World, it would seem to be derivable in the main from early Pliocene Old World Equidæ, but obviously not from any of the described forms; presumably therefore, its ancestry is to be traced mainly to an unknown Lower Pliocene fauna of northern or northeastern Asia, extending probably over northern North America. *P. proversus* might be provisionally regarded as an outlier of this fauna; *Hipparion princeps*, as an *Equus* which showed *Hipparion* blood in its ancestry by its semi-separate protocone, although otherwise a typical *Equus fraternus*. But conclusions based upon such slight evidence as we have of these two species are highly provisional and scarcely worth being taken seriously. The substance of what we know is that *Equus* shows an admixture, somewhat varying in its different species, of progressive characters, some of which are assumed earlier by typical *Pliohippi*, some by typical *Hipparions*; there is nothing in the generic characters of either genus to exclude it from the ancestry of *Equus*² but all the better-known species of each are off the direct line, although some are perhaps not excluded from participation in some degree in the ancestry of the modern horses.

¹Bull. Amer. Geol. Soc., XXIV, pp. 283-292.

²The separate protocone of *Hipparion* is due simply to the lagging of upgrowth of the commissure between protocone and protoloph in relation to the progressive hypsodonty of the rest of the tooth. Further progress could, and does in some degree, repair this structural defect of the tooth.

A.M.18972



Fig. 50. *Pliohippus leidyanus*; skull, No. 18972, one-third natural size. Upper Snake Creek beds, *Pliohippus* draw.

***Pliohippus leidyanus* Osborn**

This genus is unknown in the Lower Snake Creek, but is abundant in the upper beds. The fine (female) skeleton type of *P. leidyanus* Osborn is the best specimen secured. A fine (male) skull, a few jaws and parts of jaws, great numbers of teeth, many foot bones, etc., are referable to this species. They vary considerably in size, in proportions and pattern of the teeth, etc., but the rather characteristic form of the protocone, the amount of complication of the enamel borders (more than usual for the genus) and other distinctions of the species run fairly constant.

The male skull, No. 18972, is distinguished by the large canine teeth. The cheek teeth and skull construction accord with those of the type in most respects, but the lacrymal fossa is more clearly defined. It is a small shallow oval pit with well-defined borders, lying wholly in advance of the lacrymal bone and close above the preorbital foramen. It is chiefly in the maxilla, but the upper posterior end is excavated in the nasal bone.

The premaxilla ends abruptly just back of the nareal notch, as in the types of *P. leidyanus* and *lullianus*. This is probably a generic character of *Pliohippus* and constitutes an approach towards the conditions seen in *Hippidium*. In the Oligocene and Miocene horses the premaxilla sends a rather long, pointed process backward between maxilla and nasals behind the nareal notch. The latter is the primitive condition and is retained by *Protohippus*, *Hipparion*, and *Equus*, with certain minor but probably characteristic modifications in each group of species.

***Pliohippus supremus* (Leidy)**

A smaller species than *P. leidyanus*, with simpler tooth pattern, smaller and rounder protocone, is represented in the Upper Snake Creek pockets by upper and lower jaws and parts of jaws and great numbers of teeth. It agrees very well with *Pliohippus pernix* Marsh when specimens in a corresponding stage of wear are compared; but it also seems to be identical with the earlier described *P. supremus* Leidy. The species is more easily distinguished from the large *leidyanus* than it is from the somewhat smaller and shorter-crowned *P. mirabilis*. Many of the isolated teeth I am unable to assign with certainty to *supremus* or *mirabilis*.

If *P. pernix* Marsh is really identical with this species it affords a secure basis for correlating the foot bones, which are associated with the dentition in the types of *pernix* and *leidyanus*. The foot bones which I have correlated with the Snake Creek *P. supremus* are so much larger

than those of Marsh's type that I can hardly believe that they are the same species. They agree more nearly with *P. lullianus* Troxell, so far as comparisons can be made between adult and immature bones. This species in dentition is not far removed from *P. supremus*, and inferentially from *P. pernix*, but the much more elongate skull and larger skeleton shows it to be distinct from the latter; but I cannot find satisfactory distinctions from *P. supremus* as represented by the neotypes described by Gidley. None are cited by either Dr. Troxell or Professor Osborn.

***Pliohippus mirabilis* (Leidy)**

A considerable number of isolated teeth accord with this species as represented by the type and Mr. Gidley's neotypes, but they grade so much into the larger and more hypsodont *P. supremus* that I doubt whether they afford any real proof of the presence of the species in the Upper Snake Creek fauna. If *P. pernix* be a synonym of *P. mirabilis* it is still more doubtful, for none of the *Pliohippus* foot bones in the collections of 1908 and 1918 are as small or as slender as the type of *pernix*.

***Pliohippus* sp. max.**

A single metatarsal III, No. 17600, is much larger than those of *P. leidyanus*, equal in size and robustness to many of the *Equus* metatarsals from the Lower Pleistocene of Hay Springs quarry, but agreeing with *P. leidyanus* in the character of the cuboid and ectocuneiform facets, distal keel and some other details. No teeth conformant in size to this metatarsal are to be found in the Snake Creek collections and it may prove to be merely a gigantic individual of *P. leidyanus*.

HYPHIPPIUS

There are many fragmentary jaws and numerous teeth in the Lower Snake Creek pockets, some, Nos. 18322-4, 18326, and various specimens not numbered, about the size of *H. osborni*, while others are a little smaller, about the size of *H. equinus*, but differing from that species in a number of minor characters so that I have separated them under the name of *H. pertinax*. The type of this species, No. 17232, is a lower jaw with p_2 - m_3 complete, and Nos. 17233-4 agree closely. They are, however, very near to *H. osborni* and may prove to be only a small variety. These specimens enable me to compare the milk and permanent premolars in the upper and lower jaws. There is little difference in size but the upper permanent premolars are broader as well as higher-

crowned; p_2 is considerably shorter than its predecessor but of the same width, and p_{3-4} are slightly broader, higher-crowned but not longer anteroposteriorly.

In No. 18324 the protoloph is separate from the ectoloph on m^2 but united on m^3 ; on all the other upper teeth it is united at the base and usually nearly to the apex of the crest, although in a few teeth the union is imperfect. It is at least partially united in such milk teeth as I have examined. This character appears therefore to be subject to individual variation and can hardly serve to distinguish Merriam's subgenus *Drymohippus*, unless supported by further evidence.

In the Sheep Creek fauna *Hypohippus* is very rare, the few teeth obtained agreeing with *H. pertinax*.

Affinities of the Species of *Hipparion*

The typical species of *Hipparion* are from the Pliocene of France and a large number of species have been described from the Old World—Europe, India, China, Western Asia and Northern Africa. The Old World species have always, so far as I have seen, an oval to round-oval protocone, moderate to extreme complexity of enamel plication, premolar and molar crowns both moderately high. The round-oval protocones are shown in the Pikermi species, which is so widely known and figured that it has come to be considered (erroneously) as the type of the genus; and in this species are also shown the deep lacrymal fossa¹ and the exceptionally large lateral digits that are attributed to the genus by most writers. Other species of *Hipparion* from Samos, France, Persia, China, India, have an oval or lenticular protocone, moderate enamel plication, and one (*H. antilopinum*) is stated to be monodactyl; the lacrymal fossa is variable, but there is no true malar fossa even in the young. None of the Old World species show the extreme hypsodonty of the true molars characteristic in varying degree of *Hipparion gratum*, *lenticulare*, *plicatile* and other species of the *H. gratum* group, but in other respects they are much alike. The Californian species *M. mohavense* is distinctly nearer to the Old World species than any other American form, as pointed out by Merriam.

The American species of the *occidentale* group, namely, *H. occidentale*, *affine*, *whitneyi*, *sinclairi*, are distinguished by a marked flattening and anteroposterior elongation of the protocone, which assumes the shape of *Equus*. The premolars and molars are more nearly equal in

¹Very wide, deep and extensive with a large maxillary fossa in advance of it in the young; restricted and shallowed in adult skulls.

size and in height of crown as compared with the *H. gratum* group; the plication of the enamel varies, as it does in the European species. The protocone is almost always separate to the base, while in *H. gratum* and its allies, as also in the European *H. minor* from Samos, the protocone is frequently united with the protoloph near the base.

I am quite unable to find any adequate basis for Mr. Gidley's conclusion that the *Hipparion* teeth from Florida and South Carolina are more nearly related to the Old World *Hipparions* than those of the western United States. His statement that the protocones are round to round-oval seems to be based upon an early illustration by Leidy of a South Carolina tooth that has since been lost. With this exception all the specimens that I have seen show the usual oval form, lenticular in early stages of wear, characteristic BOTH of most Old World species and of the *H. gratum* group in the western United States. His ascription of exceptional hypsodonty to the Floridan and South Carolina species appears to be correct so far as the true molars are concerned; it is not clear that the premolars are especially hypsodont. But this is a point of resemblance to the American *H. gratum* group and NOT to the European species, in which the molar teeth are NOT unusually hypsodont. The fact is that the *Hipparions* of the southeastern United States are near allies, probably quite inseparable specifically, of the group of western and southwestern species that I have called the *H. gratum* group, but are NOT close to the Old World *Hipparions*, which find their nearest relative in California.

Palæogeographic Speculations Based Upon Supposed Affinities of the Species of *Hipparion*

Unfortunately Mr. Gidley's view of nearly twenty years ago, cited without criticism by Professor Osborn, has been seized upon by Professor Joleaud as evidence for the "Atlantis theory" so strongly advocated by many French writers. Professor Joleaud has evidently failed to notice the real Old World affinities of *H. mohavense*, also noted in Osborn's memoir, but from the supposed affinities of the "Floridan" species of *Hipparion* to Old World forms he has concluded that the genus must have reached Europe from Florida by means of a transatlantic bridge between the Antilles and Spain and North Africa, whose existence in the Eocene and Oligocene he considers to be well demonstrated and whose persistence to the Pliocene is proven by this evidence. In subsequent papers, starting from the above conclusions as proven facts, M. Joleaud proceeds to detail the migrations of various other Pliocene mammals

upon equally tenuous data, also in many instances wholly erroneous as to facts, or their significance quite misunderstood. It is to be regretted that in discussing a subject in which such wide diversity of opinion prevails, M. Joleaud has thought fit to ignore altogether the present writer's contributions (although he is not unaware of their existence) as they are based upon a detailed practical knowledge of American fossil mammals, of the character and distribution of the formations in which they are found, which are essential to the proper evaluation of the evidence, but which, naturally a European writer does not possess. This criticism is without detriment to his practical acquaintance with North African fossil mammals, which has led to some suggestions of real value that are discussed elsewhere.

Hipparion affine Leidy

A moderately large species of *Hipparion* with flattened protocone is the most abundant of all the Equidæ of the Upper Snake Creek beds. It is represented by numerous parts of upper and lower jaws and multitudes of unassociated teeth. These show a wide range in size and in practically every detail of construction, but their average character agrees best with *H. affine*. Only a few are as large and as complex in enamel folding as *H. occidentale*; on the other hand, there is some intergrading with the smaller oval-protoconed, less plicate *H. gratum*, but the two types can usually be readily separated even among the isolated teeth.

The enamel foldings are sometimes quite as complex as in *H. occidentale*, and on the other hand, they are very often as simple as in *H. whitneyi* and many of the teeth are indistinguishable from the type of this species. Some of the milk teeth agree equally well with the milk dentitions found with the type skeleton of this species. A number of metapodials and other foot bones also agree very closely with the corresponding parts of the type skeleton of *H. whitneyi*. It appears probable that this species is a synonym of *H. affine* and somewhat doubtful in my mind whether the latter is fully distinct from *H. occidentale*.

Hipparion (?) gratum Leidy

This species was based upon a few teeth but Gidley has referred to it a number of palates and jaws which serve as neotypes. To it may be provisionally referred a large number of teeth from the Upper Snake Creek beds. These are characterized by small size, usually oval protocone, simple to moderately plicate enamel, premolars of moderate

length but molars relatively small and often very hypsodont, external styles tending to be narrow on both molars and premolars (lacking the heavy premolar styles characteristic of the flat-protocone group).

I am by no means certain that these teeth all belong to one species, or that the species to which the bulk of them belong is really *H. gratum*; but they are not at present distinguishable from it. A few of the teeth are quite as long-crowned, small in cross-section, and indistinguishable in enamel pattern from the little Florida species *H. minor*; others are like the type of *H. venustum*¹; and others resemble *H. lenticulare* of Texas. It is rare, however, to find any specimens that have such round protocones as the California species *H. mohavense*, although a similar pattern of enamel plications is common enough.

Protohippus placidus Leidy

A few teeth in the 1918, 1921 and 1922 collections and a larger number in the 1908 collection are comparable with this species. The distinctive characters are the small size, very hypsodont molars, contracted lakes, partial restriction of the union between protocone and inner crescent, lake borders simple or with a few plications, external styles narrow, especially on the molars, premolars relatively brachyodont, p^2 very short anteroposteriorly. The curvature of the teeth is decidedly less than in *P. perditus* or in *Pliohippus*, more as in *Hipparion*. Most of the characters of the species are shared by the *Hipparion gratum* group but in these the protocones are separate to near the base of the tooth, the enamel usually more complexly folded and the transverse diameters of the teeth average less and they are less curved.

Protohippus perditus Leidy

A few jaws and teeth are doubtfully referred here. They are not distinguishable from the type of *P. perditus*, nevertheless they may be merely extreme variants of *Pliohippus mirabilis*, to which *P. perditus* is probably nearly related.

ARTIODACTYLA

Camelidæ are the most abundant Artiodactyla in all levels of the Snake Creek beds, with *Merycodus* a rather close second in the lower

¹Not the paratype, in which alone the round protocone is displayed. Both these specimens are lost and the comparisons are from Leidy's figure. This figure is the sole evidence on record of a round protocone in any American *Hipparion*! The other species and such undescribed specimens as I have seen have the normal oval protocone of the *H. gratum* group of this genus. *H. plicatile* has a distinctive pattern of enamel plications, but does not otherwise show anything exceptional, although its combination of very heavy mesostyle with oval protocone is unusual and more often to be found in premolars of the *H. affine* material from Snake Creek than in that of *H. gratum*.

horizons but scarce in the upper levels. Oreodonts are scarce in the lower levels, quite rare in the upper. Palæomerycids and true deer are fairly common, especially in the lower divisions. Peccaries are scarce but found in all levels. A number of rare and imperfectly known types from upper or lower levels are placed provisionally; the occurrence of true antelopids in the upper horizons is probable but not yet conclusively demonstrated.

The artiodactyls of the lower beds are not so sharply distinguished from those of the upper beds as is the case with the Equidæ; but certain broad distinctions may be made as to prevalent types in the camels and ruminants. The difficulty in distinguishing the faunas is only with fragmentary specimens.

DICOTYLIDÆ

The evolution and affinities of the genera and species of this phylum and its relations to the Old World Suina have been little studied. Following is a brief summary of certain data bearing on the subject.¹

1.—The Eocene Suina, both of Europe and America, have teeth related in construction to the Anthracotheres, preserving what is presumably the primitive pattern—upper molars five-cusped with the protoconule distinct, much broader than the four-cusped lower molars, the protocone somewhat crescentic; the upper premolars with the usual primitive pattern, an inner cusp on p^3 and p^4 .

<i>Cebochærus</i>	}	CHÆROPOTAMIDÆ
<i>Chæropotamus</i>		
<i>Chæromorus</i>		
<i>Helohyus</i>		

Whether any of these are especially related to the later Suidæ and Dicotylidæ, or whether some or all are related to the Eocene entelodonts (*Achænodon*, etc.) is not fully known.

2.—The Oligocene Suina of Europe and America are immediately distinguished by the subequal width of upper and lower molars. The premolars are still simple. The tusks are peccary-like, the upper pair dagger-like, projecting downward. The incisors are unreduced, the muzzle not elongate.

<i>Palæochærus</i>	}	SUIDÆ
<i>Perchærus</i> , <i>Thinohyus</i> , <i>Bothrolabis</i>		Subfamily
<i>Chænohyus</i>		PALÆOCHÆRINÆ

¹The following discussion was written before Miss Pearson had made the very thorough and able comparative study of American Museum Dicotylinae published in this bulletin, XLVIII, pp. 61–96, Sept. 19, 1923. I have thought best to leave it unchanged, as a basis for a more extended discussion of the phylogeny based upon her recent studies, which I hope she will find time to publish.

These are all probably nearly related and, like the greater part of the Oligocene fauna of western Europe and the United States, they represent a new invasion, presumably from central or northern Asia, which reached these two countries at about the same time.

This Oligocene group is the source of a large number of phyla, some in the Old World, some in the New, which specialize in various lines. The Old World group, or Suinæ, are nearly all distinguished by an outward growth of the upper canine. The New World group, or Dicotylinæ, never show this feature.

A.—Suinæ:

- (1.) *Hyotherium*. Simple premolars, bunodont molars, upper canine premolariform, subeverted.
- (2.) *Listriodon*. Simple premolars, tapiroid molars. The upper canine is everted in this and the following Old World phyla.
- (3.) *Xenochærus*. Molariform premolars.
- (4.) *Hippohyus*. Molars hypsodont, cemented, the cusps elongated into anteroposterior crests.
- (5.) *Phacochoerus*. Last molar hypsodont, cemented, polybunodont, premolars much reduced.
- (6.) *Potamochoerus*, *Sus*, *Babirussa*. Molars of the characteristic suid type.

B.—Dicotylinæ:

The Dicotyline group includes the American Miocene and later genera. Of these, *Desmathyus* of the Lower Miocene is an obvious connecting link with the Oligocene genera, which it nearly resembles. The remaining genera have all lost the external upper incisors (i^3); the median pair (i^1) is considerably larger than the lateral pair (i^2).

In *Prosthennops* the premolars are submolariform, in *Dicotyles* slightly more so and in *Mylohyus* completely molariform. In *Prosthennops* and *Mylohyus* the muzzle is progressively elongate and the incisors become vestigial; in *Dicotyles* the muzzle remains short. Two species of *Prosthennops* whose skulls are known show very remarkable bony expansions of the zygomata, quite diverse in type, and associated with an equal diversity in other skull characters, while the teeth differ but little. As the zygomata and back of the skull are unknown in *Mylohyus*, there is no evidence to show whether one or the other, or neither, of these species, *P. crassigenis*, *P. serus*, are ancestral to *Mylohyus*, but the genus *Prosthennops* probably stands in that relation. It is not ancestral to *Dicotyles*, unless through primitive unknown species in which the lengthening of the muzzle, reduction of incisors and peculiar

expansions of zygomata had not yet begun. And it clearly is not ancestral to *Platygonus*, which derives its peculiar type of premolars from the lower Miocene *Desmathyus* stage (see p. 180), with bicuspid bunodont premolars, tetracuspoid molars and two incisors and, like *Dicotyles*, retains the normal zygomatic arch. Species of *Platygonus* occurring in the Blanco are limitrophe forms in which the cross-cresting of the teeth is very imperfect. Three other Tertiary species which have been referred to the genus are imperfectly known, *P. rex* of the (?) Rattlesnake, known only from the molars, *P. condoni* of the (?) Mascall, *P. zieglerei* of unknown horizon (recorded as Bridger but that is impossible) are known from premolars which I have not seen.

The relations of the genera are as shown in the following table.

Recent	<i>Dicotyles</i> (Neotr.)		
Pleistocene	<i>Dicotyles</i> (Neotr.)	<i>Mylohyus</i> (Nearctic)	<i>Platygonus</i> (Nearctic)
Pliocene		<i>Prosthennops</i>	<i>Platygonus bicalcaratus</i> etc.
Miocene		<i>Prosthennops</i>	
			? <i>Desmathyus</i>
	<i>Desmathyus</i> (incl. <i>Pediohyus</i>)		
Oligocene	<i>Perchaerus</i>		

Pediohyus Loomis differs from the type species of *Desmathyus* in absence of p_1^1 ; but this may be an age character and is not alone entitled to generic rank. The type is an old individual, whereas the type of *Desmathyus* is a young adult. They are from the same horizon.

Desmathyus.— I^3 much reduced, premolars nearly simple, large dagger-like upper canine. *Desmathyus* s.s. with 4, *Pediohyus* with 3 pms. Lower Miocene.

Prosthennops.— I^2 much reduced, i^3 absent, muzzle elongate, premolars partly molariform, zygomata expanded into great ring-like processes. Upper Miocene and Pliocene.

Mylohyus.— I^{1-2} vestigial, i^3 absent, muzzle greatly elongate, premolars fully molariform, zygomata unknown, ? expanded into ring processes. Pleistocene.

Dicotyles.— I^{1-2} unreduced, i^3 absent, muzzle not elongate, premolars molariform, no expansions of zygomata. Pleistocene and Recent. All Neotropical.

Platygonus.— I^{1-2} unreduced, i^3 absent, muzzle of moderate length, premolars simple, molars tapiroid, no expansion of zygomata. Pliocene and Pleistocene.

***Prosthennops serus* Cope**

No. 17582, a fragmentary skull with the dentition excellently preserved, enables me to describe the cranial construction of this species, hitherto known only from the jaw described by Cope in 1878 and from

other fragmentary jaws. The reference of the skull is somewhat provisional. Two species of peccary occur in the Snake Creek beds, represented by lower jaws, one of which I have identified with *P. serus*. This agrees in size and in the degree of molarization of the premolars with the skull here described, but positive proof is lacking of identity with Cope's type from the Republican River. The skull differs to a remarkable degree from that of *P. crassigenis* described and figured by Gidley, so that I have grave doubts of the propriety of leaving them in the same genus, despite the apparently near resemblance between the dentitions of the two species. Subgeneric distinction at least must be made between them, as follows:

Prosthennops.—Zygomatic arch expanded into a broad flat plate. Sagittal and occipital crests well marked. Type, *Dicotyles serus* Cope 1878.

Macrogenis, new subgenus.—Zygomatic arch expanded into a massive lateral knob. No sagittal crest. Type, *Prosthennops crassigenis* Gidley, 1904.

The skull when found was broken into fragments by weathering, the palate less damaged than the rest, and the teeth fortunately intact except for the crowns of the canines. The fragments have been pieced together in great part, so that the original is reconstructed save for some uncertainty as to the exact relations of parts that could not be accurately fitted together, and the destruction of some of the more delicate regions.

The general proportions are most like those of *P. (M.) crassigenis*, especially as to the palate and facial portion of the cranium. The length of the muzzle is about the same, less than in *Mylohyus* but much greater than in *Dicotyles*. The premaxillæ are united by suture; in *Mylohyus* they are solidly coössified. The frontals are broad, nearly flat, the superior aspect defined posteriorly by distinct postorbital ridges which converge sharply to a short but prominent sagittal crest. The occipital crests diverge nearly at right angles to the sagittal crest and like it are high, sharp and narrow, and quite short, ending inferiorly in a thin warped plate. Owing to missing fragments, the relations of the occipital to the lambdoidal crest are not clear; these are formed apparently at the sutural union of mastoid and squamosal, and are rather heavy and massive. The mastoid exposure is broad, the bone being large, solid, and heavily sutured to the squamosal. The latter is also comparatively thick and heavy, the zygomatic process is broken off so that little can be seen of its character. The bulla is of moderate size, ovoid with subvertical major axis, and filled with cancellous tissue, as in all Miocene and later peccaries. The basioccipital is of comparatively light construction, the condyle like that of *crassigenis*.

The palate is of moderate width and considerably although not excessively elongate; the proportions as in *crassigenis*. The cheek teeth form a straight row with a diastema in front of the premolars; the canine is large, prominent, projects downward and a little outward and in front of it is a deep notch for the reception of the lower canine.

Two pairs of incisors are present, the median pair about twice the diameter of the lateral pair; they are considerably larger than in *P. crassigenis*, much smaller than in *Dicotyles* and set much further in advance of the canines. The canine is a stout heavy tusk with oval root about a centimeter in its major (anteroposterior) diameter; the crown is mostly broken off but it was evidently much larger than in *P. crassigenis* and accords in size with the lower canine of the type of *P. serus*. Three premolars are present, of which p^2 has three cusps and three roots, p^3 and p^4 have four main cusps and four roots, but the posterior pair of cusps is lower and smaller than the anterior pair, unlike *Mylohyus* in which they are equally developed. The molars are also quadricuspid, the third with a small heel. All the cusps of premolars and molars are round, blunt-conical, and show no tendency towards cross-cresting. They lack any tendency to polybunty and have equally lost the traces of the primitive chœropotamid pattern still distinguishable in the Oligocene peccaries and in *Desmathyus*.

The most remarkable feature of the skull is the expansion of the jugal into a broad plate with concave upper surface facing upward, outward and somewhat forward. There is some suggestion in it of the broad jugal plate of some of the larger Oreodonts, but no near resemblance. The postorbital process of the jugal is a prominent broad-based spine, which does not reach the frontal; the external border of the plate is convex, somewhat thickened and rugose, the whole upper surface being slightly roughened. A nearer approach in type, although less specialized, is seen in some of the Suinæ, e.g., *Hylochærus*.

Dicotylid, cf. *Desmathyus*

No. 18952, a badly smashed upper jaw from Stonehouse draw quarry, retains dp^3 and m^1 nearly complete and shows that a large peccary existed in the *Merychippus primus* fauna. It is readily distinguished from the described species of *Desmathyus* and *Prosthennops* by the greater size and breadth of the teeth, which have the same general construction as in these genera. As it is probable that other and better specimens will be found by future explorations, I do not name it at present.

A second upper jaw fragment found in the same quarry in 1923 shows dp^3-m^1 , with p^{3-4} preformed in the jaw. The premolars are simply bicuspid, as in *Platygonus*; the molar retains the primitive bunodont quadricuspid construction of other Tertiary dicotylids, and is about as wide as it is long. This appears to be a possible ancestor of *Platygonus*.

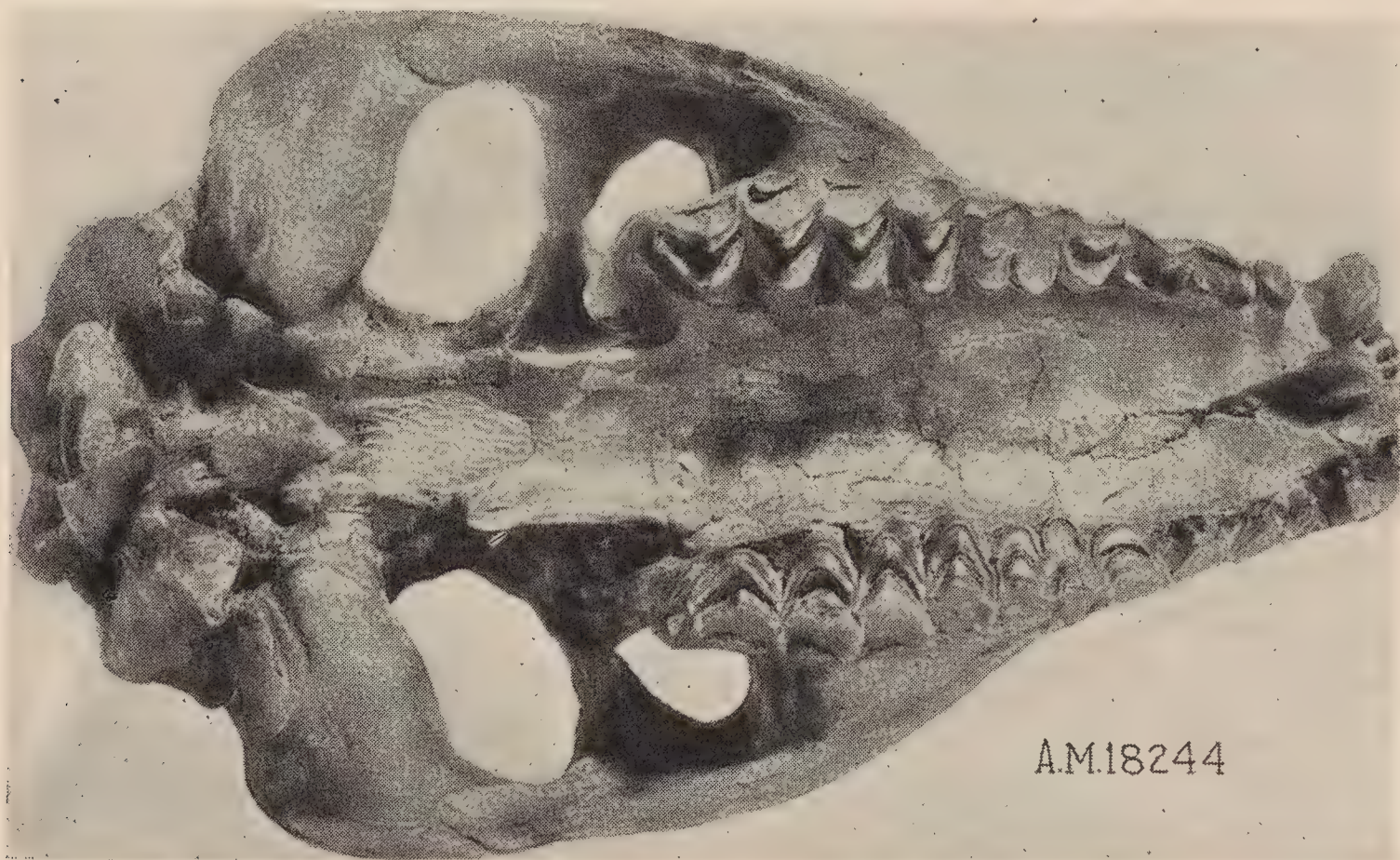


Fig. 51. *Pronomotherium siouense*; skull, palatal view, two-fifths natural size. No. 18333, Snake Creek beds, *M. paniensis* zone. 18244 by error in figure.

AGRIOCHÆRIDÆ (Oreodontidæ)

This family is represented in the Lower Snake Creek horizon by the extraordinary genus *Pronomotherium*, by at least two well-defined species of the *Merychys* group and probably by others. In the upper level we have positive evidence of one species, described from a lower jaw in 1909 as *Merychys* (*Metoreodon*) *profectus*. Upper jaws can now be correlated with the type and indicate that it is identical with *Merychys major* Leidy, based upon an upper jaw with p^3-m^2 . The horizon of *Metoreodon relictus* is doubtful, probably Lower Snake Creek.

Metoreodon major (Leidy)

Syn.: *M. profectus* Matthew and Cook

The type of Leidy's species is from some point on the Niobrara River and the fine skull from Devil's Gulch, Brown County, Nebraska, recently described and figured by Barbour and Cook,¹ may be a topo-

¹1917, Nebraska Geol. Sur. Reports, VII, pp. 165-172.

type and is certainly not far removed in locality and horizon. For this reason it seems advisable to assume that the Snake Creek species is really, as it appears to be, identical with Leidy's type as well as with the Devil's Gulch skull which has been referred to *M. profectus*. There is, at all events, no question of the close alliance between them and of the generic distinctness of Leidy's type, along with the Snake Creek *M. profectus* material and the Devil's Gulch skull, from *Merycochærus*, *Pronomotherium*, *Ticholeptus*, or *Merychys*.

Metoreodon was based upon the more complex construction of the lower premolars as compared with *Merychys* or *Merycochærus*. This is confirmed by the upper premolars, which are quadrate in outline, longer than wide, the anterointernal and posterointernal crests equally developed on both p^2 and p^3 , united with the outer crescent respectively by anterior and posterior marginal crests, separated from each other by a medial internal crest running inward from the apex of the outer crescent to the internal basal cingulum.

The incisors in this genus are pointed and not broadly spatulate, the upper canine of moderate size, a slight diastema behind it, the upper premolars close set, narrow transversely, relatively hypsodont; the premaxillæ are solidly coössified, the infraorbital foramen is above p^4 or the anterior end of m^1 .

As Loomis has observed,¹ *Metoreodon* is probably nearest to *Mesoreodon* and *Ticholeptus*, and is not close to *Merycochærus* and *Pronomotherium*, in spite of the considerable resemblance in teeth.

I suspect that *Pronomotherium californicum*² belongs in this genus rather than in the one to which Dr. Merriam has provisionally referred it. The upper premolars agree more closely with *Metoreodon* than they do with *Pronomotherium* and the infraorbital foramen has the same position as in *P. profectus* and *relictus*, whereas in *Pronomotherium* it is much further back, approximately over m^2 or m .³

***Metoreodon relictus* Matthew and Cook**

Two small oreodonts are represented in the Lower Snake Creek fauna besides the large *Pronomotherium*. They are alike in size and in most other respects, except for the characters of the premolars, which in one are simple, p_1 large, and agree with *Merychys*; in the other they are decidedly more complex, p_1 is small and premolariform and the details agree with the type of *M. relictus*. But no specimens of *Metoreodon*

¹Loomis, F. B., 1920, Amer. Journ. Sci., L, p. 289.

²Merriam, J. C., 1919, Publ. Univ. Calif., Dept. Geol., XI, p. 575.

relictus are included in the 1918 material from Quarry 1 (upper level) and in default of this positive evidence (which was to be expected) of the species belonging to the later fauna, it must be retained as doubtful.



Fig. 52. *Pronomotherium siouense*; side and top views of skull No. 18333, two-fifths natural size. 18344 by error in figure.

***Pronomotherium siouense* Sinclair**

TYPE.—No. 12057 Princeton Mus., a lower jaw from Horizon A of the Snake Creek beds, at Sinclair draw.

NEOTYPE.—No. 18333, a finely preserved skull from the lower Snake Creek, Quarry B, expedition of 1921.

SPECIFIC DIAGNOSIS.—Somewhat smaller than *P. laticeps*, considerably smaller than *P. altiramum*, and intermediate between the two in form of muzzle.

The neotype is compared with the skulls of *P. laticeps* in the Carnegie Museum and of *P. altiramum* in the American Museum. It is more perfectly preserved than either, but lacks an associated lower jaw. Four lower jaws from the same quarry are referred to the species.

The nasals have been lost but the position of the naso-frontal sutures, flush with the superior surface of the frontal bones, shows that the nasals projected sharply upward as in *P. laticeps*; the recession of the nares is less extreme than in that species, the skull is flatter, the superior border of the maxillaries and premaxillaries is less convex and shorter.

The generic characters, great recession of the nares, which are extended from the principal opening above downward and forward in a long slit between the superior border of the maxillary and premaxillary to within a short distance of the front of the skull, are evident in this skull as in *P. laticeps* and *altiramum*. The basicranial region is peculiarly shortened and bent sharply downward relatively to the basifacial plane, the paroccipital process, bulla and postglenoid process greatly crowded together, the bulla of very small diameter but extended downward as an elongate finger-like process filled with cancellous tissue, somewhat as in the Suidæ. The condyles face largely downward in relation to the palatal plane. Other features peculiar to the genus have been described in detail by Douglass¹ in the skull of *P. laticeps*.

Pronomotherium appears to be in most respects an extreme specialization along the lines of *Merycochærus* but has not the broad lateral expansion of the occiput formed from the lambdoid crest of the squamosal, as described by Matthew in that genus.² It had, undoubtedly, some peculiar type of proboscis developed. The skull has some analogies to the type of *Saiga* and others to the tapir, but a careful study and reconstruction of the facial musculature is necessary before its character can be scientifically restored.

***Pronomotherium siouense*, variety**

A number of upper and lower jaws from the Sheep Creek beds at Stonehouse draw (Sheep Creek, Hor. A.) are referable to the genus and not positively distinguishable from *P. siouense*. I regard them provisionally as a variant, and specify as type No. 18344, upper jaw. The size is a little larger throughout, the premolars, especially the anterior ones, proportionately larger and more robust but not showing any clearly distinctive construction.

¹Douglass, Earl, 1900, Amer. Journ. Sci., X, pp. 428-438 [*"Merycochærus" laticeps*].

²Matthew, W. D., 1901, Mem. Amer. Mus. Nat. Hist., I, part 7, pp. 397-418.



Fig. 53. *Pronomotherium siouense*; lower jaw, half natural size, external, superior and internal views. No. 18334, Snake Creek beds, *M. paniensis* zone.

CAMELIDÆ

The large progressive *Megatylopus gigas* is now known to be from the Upper Snake Creek beds. While not so far advanced as are some of the Blanco camelids, it approaches them and is probably in their line of ancestry. It is allied also to the Pleistocene *Camelops* but cannot be ancestral to this form, as it is decidedly more cushion-footed, equalling the modern camel in this respect. On the other hand, the small and primitive *Protolabis princetonianus* (= *P. fissidens*) and other species of *Protolabis* and *Procamelus* come from the Lower Snake Creek beds. These are more nearly related to the Pawnee Creek species. *Alticamelus*, which is a side branch with very elongate limbs, progressive as to feet and front teeth, conservative as to cheek teeth, is present in all three horizons. This was to be expected, as it occurs in the Republican River fauna and also in the Pawnee Creek Miocene, and is probably quite directly descended from certain species of *Oxydactylus* of the Lower Miocene of Nebraska.

A considerable number of skulls and a large series of upper and lower jaws, limb and foot bones from each of the three horizons is available for comparison. There is, with a few exceptions, no association of skull and foot parts. The type of "*Alticamelus*" *procerus* Matthew and Cook, 1909, includes considerable part of the skeleton in association with skull and jaws. The type of *A. priscus* infra, and a few other specimens out of the Sheep Creek beds, also have skull and skeleton parts associated. *Megatylopus gigas*, Matthew and Cook, 1909, has an ulnoradius rather doubtfully associated with the skull. The Pawnee Creek beds, with a fauna largely identical, have supplied the positive evidence on correlation of skull and feet in some other species.

***Alticamelus procerus* Matthew and Cook**

The type of this species, No. 14070, consists of the skull, jaws, hind limb and parts of the fore limb and a number of vertebræ. Re-examination in 1922 of the point where this specimen was excavated shows that it is from the *M. paniensis* zone in Sinclair draw. It is always a possibility that a small pocket from the upper channel-beds was let into the lower horizon at this point but there is no evidence of it and the specimen must be recorded as of the *M. paniensis* zone, although the referred specimens are chiefly from the *Hipparion affine* zone.

The absence of incisors 1 and 2 is demonstrated in the type, the cheek teeth being only moderately worn.

A number of additional specimens, upper and lower jaws, found in 1916 and 1921, agree with the type, besides various limb and foot bones.

Alticamelus leptocolon Matthew

The type, No. 9115, consists of parts of the lower jaws and feet from the Pawnee Creek beds. The species is quite common and characteristic in that formation. In the Lower Snake Creek it appears to be equally common and is represented by one or more skulls and many upper and lower jaws, limb and foot bones. It is distinguished from *A. procerus* by smaller size, molars with less relative transverse width, inner crescents of premolars less developed, the inner crescent usually incomplete on p^3 and wholly absent on p^2 .

Alticamelus priscus, new species

TYPE.—No. 14189, a skull with atlas and axis vertebræ, tibia and pes.

HORIZON AND LOCALITY.—Sheep Creek beds, *Merychippus* draw, probably Horizon A, Exped. 1908.

CHARACTERS.—Skull with the elongate proportions, broadly excavated facial fossa and other characters of *A. procerus* and *A. leptocolon* but of smaller size throughout. Axis, tibia and metatarsus extremely long and slender, metatarsals completely united but not expanded distally. Premolars unreduced. Molars and incisors 1–2 not preserved in the type.

An incomplete skull, a number of upper and lower jaws, limb and foot bones found in 1922 are referred to this species.

Protolabis angustidens Cope

The type is a lower jaw from the Pawnee Creek Miocene, A. M. N. H. No. 8294. *P. heterodontus* Cope, the type of the genus, is not clearly distinguishable although somewhat larger and more robust. Both have the large caniniform teeth and heavy muzzle which I assume to be distinctive of the male, the supposed females having very much smaller front teeth, although not different in premolars and molars.

I refer to this species No. 18348, skull of an old male, and 18349, front of skull and lower jaws of adult female, besides a number of palates, jaws, limb and foot-bones. The skull is about the size of *A. leptocolon* and very similar in general proportions; the premolars are much smaller but the molars are scarcely distinguishable from those of *A. leptocolon*. The condyles of the skull are smaller, as befits the smaller skeleton, and the limbs and feet are relatively smaller and less stilted. The association of the feet is based upon the proportions of referred specimens of the species from Colorado, Nos. 9100, 9425, which show the metapodials partly united in the proximal half, but never solidly united as they are in *Alticamelus*.

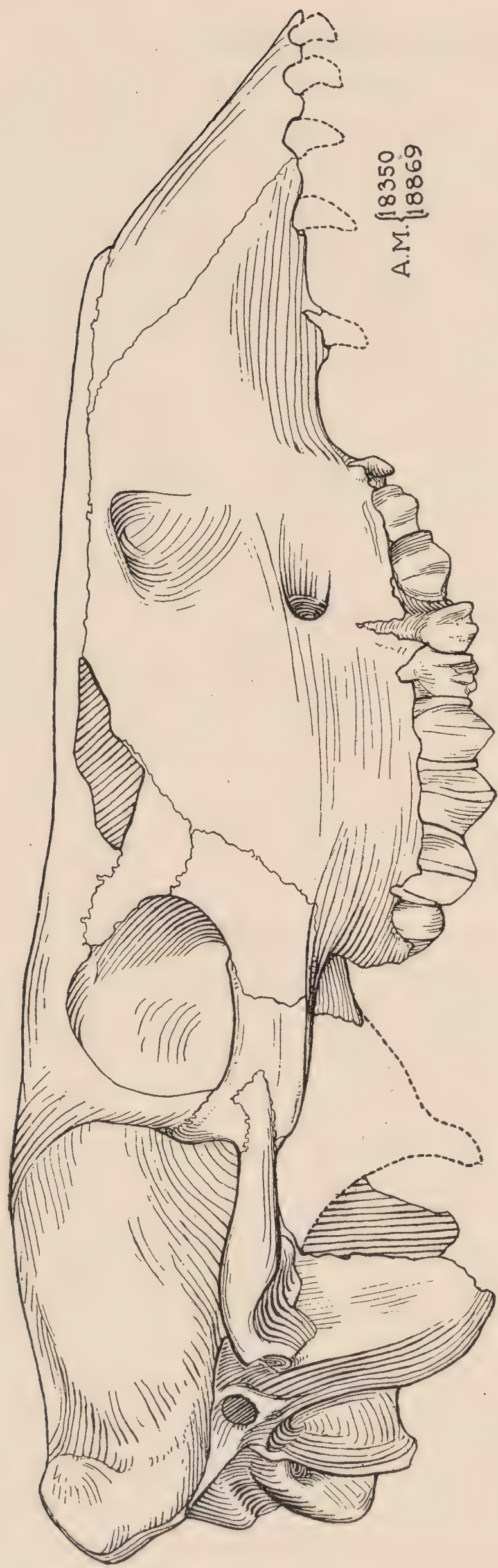


Fig. 54. *Alticamelus* cf. *leptocolon*; skull, half natural size, Snake Creek beds, *M. paniensis* zone.

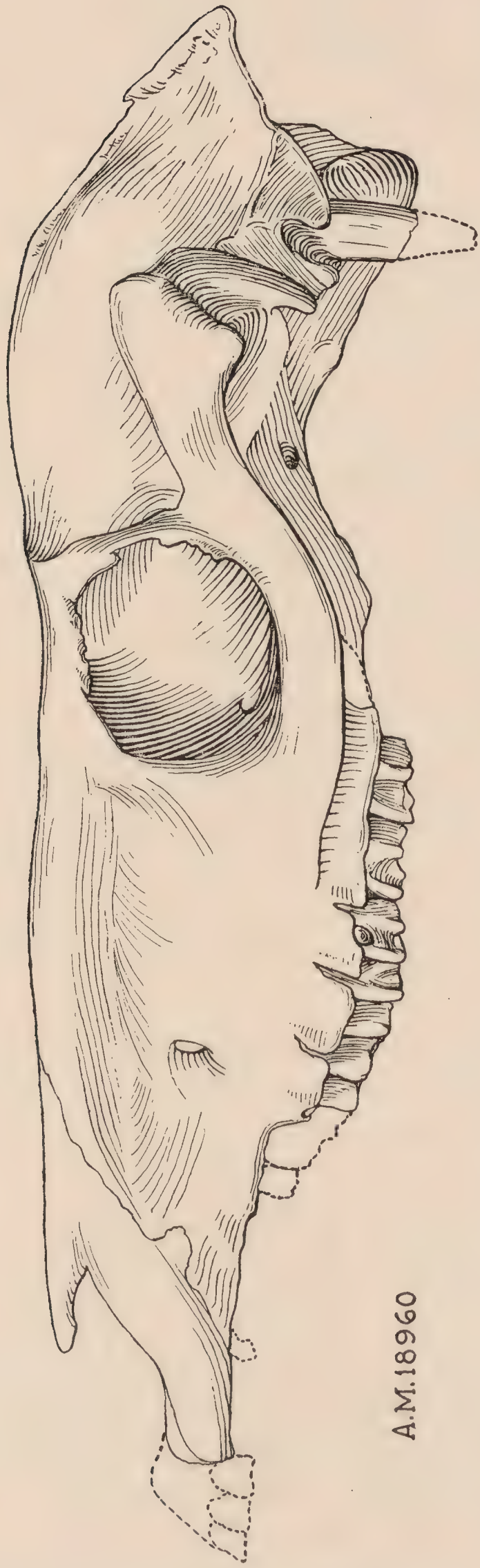


Fig. 55. *Merychippus primus*; skull, half natural size. No. 18944, Sheep Creek beds, *M. primus* zone. See p. 162.

A palate, No. 18963, and various upper and lower jaws, limb and foot-bones from the Sheep Creek beds, chiefly from Stonehouse draw quarry, are provisionally referred to *P. angustidens*. A larger series and more complete material from the *M. primus* and *M. paniensis* zones might demonstrate constant distinctions in the two horizons.

***Protolabis fissidens* Cope**

Synonym: *P. princetonianus* Sinclair

The type of *P. fissidens* is a lower jaw, parts of both rami, from the Pawnee Creek beds of Colorado, A. M. N. H. No. 8297, Cope Coll. With this specimen a number of lower jaws in our collection agree very closely. The fine skull which Sinclair used for type of his species accords in size, proportions and character of premolars and molars with the lower jaws referred to *P. fissidens*, and the lower jaw referred by Doctor Sinclair to *P. princetonianus* agrees quite exactly. A complete skull and various parts of skulls, palates, jaws, and limb and foot-bones from Stonehouse draw are referred to *P. fissidens*. It appears to have been the most abundant of the camels of this horizon.

This apparently fixes the affinities of this species as one of the *Protolabis* group related most nearly to *P. longiceps* of the Pawnee Creek and like it retaining i^{1-2} unreduced, as in *Miolabis*, but with longer-crowned teeth than in *M. transmontanus* of the Mascall (genotype of *Miolabis*).

Other specimens referred to *P. fissidens* are from the Lower Snake Creek, Horizon A.

To this species should probably be referred various separate metapodials and limb bones of a small form which had previously been provisionally referred to *Procamelus*.

***Protolabis saxeus*, new species**

TYPE.—No. 18960, skull from Stonehouse draw quarry, *Merychippus primus* zone.

DIAGNOSIS.—Size considerably smaller than *P. heterodontus* and *angustidens*, about the same as *Miolabis longiceps* or *fissidens*, but in proportions and character of the teeth quite like the larger species. A small but rather deep facial fossa, sharply defined above, lies in advance of the lacrymal vacuity and above the premolars. The upper incisors are not preserved in the type but their alveoli indicate some reduction of i^{1-2} , although less than in *P. heterodontus*.

Various specimens referable to this species agree fairly well in characters, but show a considerable amount of variation. A second skull, No. 18961, lacking the occiput, is an older individual of somewhat larger

size and the facial fossa is quite shallow, the roots of p^1 more divergent. In a number of jaws grouped under 18962, the caniniform teeth show the usual sex difference in size, accompanied by a corresponding difference in robustness of the anterior part of the jaw (both skulls are females) and some individual variation in size and details of construction of the cheek teeth.

Various limb and foot bones of appropriate size from the Stonehouse draw quarry are also referable here. They show the median metatarsals completely united, save in young individuals, while the median metacarpals are united only in the proximal half.

Miolabis tenuis, new species

TYPE.—No. 18965, a lower jaw, left ramus and symphysis.

HORIZON AND LOCALITY.—Sheep Creek beds, Horizon A, Stonehouse draw.

CHARACTERS.—Symphysis shallow, flaring and a long sharp-crested diastema between the canine and the cheek teeth; p_1 absent, p_2 vestigial, p_3 and p_4 small and rather short, molars of normal camelid construction, the anteroexternal pillar prominent on m_1 and m_2 , the anterointernal pillar prominent on m_2 .

This species is considerably larger than *Pliauchenia minima* Wortman and the premolars are much less compressed, but the peculiar deer-like lines of the diastema are somewhat the same. It is smaller than *M. longiceps*, the premolars are relatively smaller, the diastema between canine and cheek teeth is longer and more crested, the accessory pillars are well developed on two molars while they are entirely absent in *M. longiceps*. These appear to be the nearest relatives of the present species.

The reference to *Miolabis* is provisional, based principally upon the apparent affinity to *M. longiceps*. The reduction of the premolars is carried further in No. 18966, a lower jaw with well worn teeth; the second and third premolars have disappeared and their alveoli closed; the size and characters of the remaining teeth accord with the type of *P. tenuis*, except that the anterior pillars on the molars are almost gone, probably through wear, as the pillar disappears towards the base of the crown in all Camelidæ which possess it.

A skull of this species with one ramus of the lower jaw was obtained in 1923 from the same quarry as the type. The muzzle is elongate and extremely slender. The incisive alveoli indicate three teeth of moderate size projecting strongly forward; the canines are small and p^1 absent except for a small alveolus on one side only. The posterior premolars and m^1 are represented only by alveoli, but apparently p^2 is absent, p^3 two-rooted, and p^4 has a good-sized internal root. The premaxilla,



A.M.18965

Fig. 56. *Miolabis tenuis*; lower jaw, natural size, superior and external views. Type specimen, No. 18965, Sheep Creek beds, *M. primus* zone.

though slender anteriorly, has a long and wide nasal suture. This skull evidently differs widely from the type of *M. transmontanus*, but may be more nearly related to *M. longiceps*.

CERVIDÆ

(Including Palæomerycidæ and Moschidæ)

Three distinct phyla at least are represented in the Snake Creek faunæ. Of these *Dromomeryx* and *Blastomeryx* have been clearly defined by Douglass and Matthew, the former large, very brachyodont, with stout postorbital horns of giraffoid type; the latter small, semi-brachyodont, hornless, with large laniary upper canine tusks like *Moschus*. One species of the third group has been provisionally referred to *Cervavus* Schlosser, which is typical in the Chinese Pliocene (*C. oweni*, *C. kokeni*). The species described by Scott in 1890 as *Blastomeryx* is perhaps of the same type. Lull's *Blastomeryx marshi* and *Aletomeryx gracilis* also need to be considered in this connection; unfortunately, their exact geological horizon is uncertain, as is that of Scott's *Blastomeryx* "*gemmifer*."

Dromomeryx whitfordi Sinclair

There is nothing to add in regard to this genus. A number of upper and lower jaws representing a single species of *D. whitfordi* have been found in the *Merychippus paniensis* zone and various limb and foot bones of appropriate size and characters. I have not identified this phylum in the beds above or below. The horns are the most characteristic feature, long, straight, supraorbital, with a wide posteroexternal flange. The characteristic features of the teeth are their short crowns, great breadth and massiveness, strongly rugose enamel, "palæomeryx fold" well developed and traceable even on half-worn teeth, the inner heel-cusp of m_3 well developed, tending to separation from the outer heel-cusp and to union with the posterointernal cusp (entoconid); the inner pillar of p_4 extended into a wide anteroposterior crest; a corresponding but rudimentary extension on p_3 .

BLASTOMERYX

The typical species is *B. gemmifer* of the Pawnee Creek and topotypes have been described by Matthew in 1901. This is a much smaller species than the *Blastomeryx gemmifer* of Scott, 1890, which is hereinafter renamed **B. scotti**. The Lower Miocene species referred to the genus cover a considerable range of variation and include apparently two phyla

whose further progress can be traced in the Miocene and Pliocene of the Snake Creek quarries. These later stages are unfortunately incompletely known; the Lower Miocene (Upper Rosebud, Upper Harrison) species *B. advena* and *B. marshi*, each known from skeletons in this museum, differ in size and proportions and may prove to belong to entirely distinct genera. The former is hornless and has a large canine tusk, the latter has rudimentary horns and a small tusk.

The two Lower Miocene species are succeeded in the Middle Miocene (Lower Sheep Creek beds) by the species hereinafter described as *B. medius* and *B. riparius*. The former is intermediate in size and characters between *B. advena* of the Lower Miocene and *B. elegans* of Upper Miocene (Snake Creek A), the latter between *B. marshi* and *B. sinclairi* of the Upper Miocene. Both lines appear to be represented in the Lower Pliocene but by very imperfect specimens.

The first phylum increases very little in size but distinct steps can be observed in the changes of tooth pattern. Cope's name *Blastomeryx*, type *B. gemmifer*, applies in a more restricted sense to this phylum. In the second phylum, which may be distinguished as a subgenus under the name **Dyseomeryx**,¹ there is a considerable increase in size, some changes in tooth pattern, but not any marked increase in horn development. Possibly more material would show that the horn increased in the male.

Lull's *Aletomeryx* does not differ widely from *Dyseomeryx* in teeth but has simpler premolars, much longer horns and a very different shape of skull (if Lull has correctly assembled his material). It seems likely that it represents a nearly related phylum but deserves full generic separation.

The Lower Miocene stage of *Dyseomeryx* is best represented in our collection by No. 14264, two skulls with part of the skeleton associated, including good fore and hind limbs. It is from the Upper Harrison beds near Agate, Nebraska, collected in 1908. It agrees very nearly with *Blastomeryx marshi* Lull, 1920, so that I refer it to that species, which is based upon a skull and jaws of unknown horizon and doubtful locality.

The next stage, from the Lower Sheep Creek, is represented by an upper and several lower jaws, various foot bones, etc., not associated, and is described below under the name of *B. (D) riparius*.

The third stage is the species which I have heretofore referred to "*Cervavus*" under the name of *C. sinclairi*: an incomplete skull together with various upper and lower jaws, teeth and foot bones and a partial skeleton, jaws and jaw fragments from Pawnee Creek beds.

¹Gr. *δυσος* = sunset, *μῆρυξ* = ruminant. In allusion to its habitat in the western United States.

A fourth stage perhaps, although not clearly distinguishable from the third, is the species described by Professor Scott as *B. gemmifer* and here re-named *B. scotti*. The type is the skull fragment described by Scott and such other parts as pertain to it in the Garman "Loup Fork" collection, probably from the Valentine horizon. From this horizon there are in our collection a number of upper and lower jaws, front bones, etc., but nothing associated. Most of them are from South Dakota, some from Nebraska.

The latest stage in the series is from the *Pliohippus leidyanus* zone at Snake Creek, a large species represented by parts of jaws, teeth and other fragments. The species also appears in the Republican River fauna of that valley in Kansas, Nebraska and Colorado, but I do not know of any good specimens suitable for types.

Possibly *Odocoileus* may represent the final stage of this phylum, but I think it very improbable.

The more typical *Blastomeryx* is represented in the Lower Miocene by the skeletons of *B. advena*, *primus* and *olcotti*, which I described in 1907; in the Middle Miocene by lower jaws, upper teeth and foot bones from Sheep Creek A, at Stonehouse quarry; in the Upper Miocene by *B. gemmifer* of the Pawnee Creek and *B. elegans* of the Snake Creek, and in the Lower Pliocene by *B. wellsi*.



Fig. 57. *Blastomeryx medius*; lower jaw, natural size, external view. Type specimen, No. 18955, Sheep Creek beds, *M. primus* zone.

***Blastomeryx medius*, new species**

TYPE.—No. 18955, a lower jaw from the Sheep Creek beds at Stonehouse draw, Hor. A, Exped. 1922.

DISTINCTIVE CHARACTERS.—Size of *B. advena* and resembles that and other species of the Lower Miocene in the simple construction of m_3 , lacking the postero-internal pillar; but differs from the Lower Miocene species and resembles *B. elegans* in the pillar in front of middle internal crest of p_4 .

Blastomeryx elegans Matthew and Cook

Type: No. 14101, lower jaw from the *paniensis* zone, Snake Creek A, figured and described by Matthew and Cook in 1909. Various jaws and skeleton bones in the collections of 1916 and 1921 are referred here.

Blastomeryx cf. **wellsi** Matthew

Type: No. 9823, part of lower jaw from the Valentine beds, Little White River, S. Dakota, figured and described by Matthew in 1904.

DYSEOMERYX, new subgenus

Dentition as in *Blastomeryx* but posterior end of main crest of p_4 extended inward to form a fourth transverse crest; palæomeryx fold vestigial; entoconid of m_3 more or less united to internal cusp of third lobe; size progressively larger; rudimentary horns at upper posterior angle of orbit; lateral digits of manus complete or with part of metacarpal shaft missing. Type, *B. marshi* Lull, 1920.

Blastomeryx (**Dyseomeryx**) **marshi** Lull

No. 14264 is a partial skeleton with an extra skull and jaws associated, found by W. D. Matthew in 1908 in the Upper Harrison beds of Nebraska. Unfortunately, neither skull is complete and the skeleton is in bad preservation. So far as comparisons can be made, it agrees very closely with Professor Lull's type, which is believed to have been collected near the Niobrara River at a point not far east of Antelope Creek. I do not know of any Lower Miocene formation along this part of the river but the Upper Rosebud is not very far to the north of it and there is sufficient uncertainty about the record of the type to warrant the reference of the Lower Miocene skeleton to the species.

No. 14264 is a considerably larger animal than the typical *Blastomeryx*, has rudimentary horns, a vestigial palæomeryx fold, anterior cannon bone complete and lateral digits of the forefoot complete, although the shaft is reduced to a thread, the lateral digits of the pes probably reduced to small, partly coössified proximal splints; at all events, no evidence remains of any distal vestiges. Ulnar shaft complete and separate throughout.

The size of the species is nearly that of the dorcas gazelle but the proportions of the limb segments are quite different, the metapodials much shorter, the humeri longer and heavier. It agrees much more nearly in proportions with the brocket but is rather smaller throughout.

Professor Lull has published a restoration of a topotype specimen of *B. marshi*, but has not described the skeleton in any detail, so that I am unable to verify the identification of our specimens.

Blastomeryx (Dyseomeryx) riparius, new species

TYPE.—A left upper jaw with p^3 – m^3 , No. 18956 from Stonehouse draw quarry; paratypes, Nos. 18958, lower jaws from the same quarry. All Hor. A of Sheep Creek beds, Exped. 1922.

In size this is a fair intermediate between *B. marshi* of the Lower Miocene and *B. ("Cervavus") sinclairi* of the Upper Miocene. The premolars are comparatively small, p^3 slightly longer than wide, with complete inner crescent, a posterointernal cingular crest, a deep external notch just behind the anteroexternal angle. The upper molars moderately brachyodont, m^2 and m^3 of equal size, m^1 somewhat smaller, the surface somewhat rugose but not as much as in *Dromomeryx*, the inner basal



Fig. 58. *Dyseomeryx riparius*; upper jaw, crown view of teeth natural size. Type specimen, No. 18956, Sheep Creek beds, *M. primus* zone.

tubercles quite small. The posterior wings of the hypocone crescents and anterior wings of the protocone crescent unite early to the outer crescents at the posterior and anterior angles of the tooth; the posterior wing of the protoselene unites a little later to the flank of the hyposelene, while the anterior wing of the hyposelene remains separate, although close to the posterior wing of the paraselene.

In the lower jaw the molars show the moderate brachyodonty of *Blastomeryx* but the internal talonid cusp of m_3 is more or less completely united with the hypocoid, the large external talonid crescent looping around the back of the tooth in the usual manner. The basal cusp between the outer crescents of the molars is distinct and the anterior basal cingulum rather prominent.

Of the lower premolars the second is rather small but has the median and posterior transverse crests; the third and fourth have the median transverse crest expanded internally into a round pillar, the anterior one rudimentary, the posterior one well developed, while the main external crest is curved around at its anterior and posterior ends until it reaches the inner border line of the tooth (distinction from *Blastomeryx* proper and from *Merycodus*).

Blastomeryx (Dyseomeryx) species

The occurrence in the upper beds of a species resembling *Blastomeryx sinclairi* of the lower horizon but larger and more robust, is shown by a lower jaw fragment with m_{2-3} and some separate teeth.

Blastomeryx (Dyseomeryx) sinclairi (Matthew)*Cervavus sinclairi* Matthew, 1918

To *B. (D) sinclairi* is referred an incomplete skull, No. 18879, from Sheep Creek quarry, Sinclair draw, Expedition of 1921. The horizon is Lower Snake Creek (Hor. A).

The front teeth are not preserved and the cheek teeth are so much worn that they give little in the way of definite characters. The orbit is rather large and only moderately prominent and above it at the posterosuperior angle is a small rudimentary horn. The face is depressed upon the basicranial axis to a moderate degree, about 15° . The lacrymal vacuity is a long and narrow slot, apparently like that of *Antilocapra* but more elongate. The nasals and premaxillæ are not preserved and the anterior borders of the maxillæ broken. The position of the orbit also is about as in *Antilocapra*, its anterior border being wholly behind the line of the last molar. The rudiment of horn projects outward and upward from the border of the orbit; in does of *Odocoileus* slight swellings appear at the posterior angles of the frontals and about half-way between those points and the orbital margins; in female *Capreolus*, a swelling just in advance of the posterior angle of the frontal; in the present species the horn is situate as in *B. marshi* and *Aletomeryx* but the orbit is as in *Antilocapra*.

The premolars are simpler than in *Dromomeryx*; p^{2-3} both have strong median internal cusps but the inner crescent is not completely formed; the anteroposterior diameter exceeds the transverse in both teeth, though more considerably in p^2 . The premolars of *Aletomeryx* are much simpler, p^2 wholly lacking an internal crest, while that of p^3 is no more developed than in p^2 of the species of *Dyseomeryx*.

ANTILOCAPRIDÆ

Merycodus is fairly common in the *Merychippus primus* zone, this being the earliest record of its occurrence. The upper and lower jaws, limb and foot bones do not show any uniform distinctions from the more abundant material secured in the *M. paniensis* zone. It is quite possible that skulls or antlers might show such distinctions.

Merycodus appears at this point as an invading immigrant, so far as we can judge. There is nothing in the extensive and well studied fauna of the Lower Miocene that could stand as ancestral to it. It appears suddenly, just as *Blastomeryx* appears suddenly at an earlier point (Upper Rosebud and Upper Harrison).

AM.18958



Fig. 59. *Dyseomeryx riparius*; lower jaw, external view, natural view. No. 18958, Sheep Creek beds, *M. primus* zone.

The species of *Merycodus* are very much confused and at present can be straightened out only in a provisional way. The species from Snake Creek A appears to be distinct from *M. osborni* of Pawnee Creek, and both from *M. furcatus* of the Valentine and Republican beds. The position of *M. necatus* is not clear; it was based upon jaws from Bijou Hills, but no topotype antlers are known. The Bijou Hills fauna is probably Middle Miocene, at least as regards the specimens first collected there by Hayden; and the specimens from Horizon A, Sheep Creek, should therefore be correlated with *M. necatus*. Unfortunately, they do not include antlers. The *Merycodus* from the Upper Miocene at Snake Creek (Hor. A) has been described as a variant of *M. necatus*, *M. n. sabulonis*, M. and C., 1909, and in default of contrary evidence I continue this identification provisionally. *Cervus warreni* Leidy is closely allied to *M. osborni* and may prove identical, although presumptively from a different geological horizon (Valentine beds). The New Mexican specimens referred by Cope in 1877 to "*Dicrocerus*" *furcatus*, including those described in 1874 as *Cosoryx ramosus*, appear to me to be also closely allied to *M. osborni* and probably identical with *C. warreni*, but distinct from *M. furcatus*. His *D. tehuanus* is hardly distinguishable; it is known only from a number of small jaws of varying size, of which Cope selected the smallest for his type; measurements of the teeth, however, have little significance when their dimensions vary so widely with age and wear as they do in ruminants. His *D. teres* and *trilateralis* are possibly members of the *Dyseomeryx* phylum of *Blastomeryx*; they have not the horn characters of typical *Dromomeryx* and there is no reason to associate them with *Merycodus*, as the teeth are not known.

Key to Species of *Merycodus*

- 1.—Antlers with short beam, long tines, forked near the base, often three-tined.
 - M. osborni* Matthew, 1904.....Pawnee Creek, Upper Miocene.
 - M. warreni* Leidy, 1858.....Valentine, Lower Pliocene.
 - M. ramosus* Cope, 1874.....Santa Fé, Lower Pliocene.
- 2.—Antlers with long beam, short tines, never more than the single fork.
 - M. furcatus* Leidy, 1869.....Valentine, Lower Pliocene.
Republican R., Lower Pliocene.
- 3.—Antlers with short beam and short tines, never more than the single fork.
 - N. necatus sabulonis* M. and C., 1909.....Snake Creek A, Upper Miocene.
 - M. necatus* Leidy, 1854.....Bijou Hills, (?) Middle Miocene.

? *Merycodus altidens*, new species

TYPE.—A. M. N. H. No. 18981, lower jaw fragment with m_3 ; paratypes, No. 18981a, last upper molar, and No. 18981b, last lower molars.



Fig. 60. *Merycodus altidens*; lower molar m_3 , and fragment of lower jaw with m_3 in place. Both inner views, natural size. Upper Snake Creek beds.

HORIZON AND LOCALITY.—All from Snake Creek beds (upper level), Quarry No. 1 and *Pliohippus* draw.

SPECIFIC CHARACTERS.—The chief distinctive features as compared with *M. necatus* are (1) size one-half larger lineally; (2) fourth lobe on m_3 and posterior lobe of m^3 well developed and distinct from crown to base; (3) last molar more hypsodont.

The species is very clearly distinct from any described but whether it belongs to *Merycodus* is doubtful until more complete dentition and skull are known.

AFFINITIES OF *Merycodus*.—In a previous contribution I made some comment upon the views of Doctor Winge as to the affinities of *Merycodus* and *Antilocapra*. A recent discussion by Doctor Hilzheimer¹ of the

¹1922, Centralblatt f. Min., Geol. u. Pal., p. 745.

Markische Museum, Berlin, calls for more careful consideration. The author gives an able and well-considered argument for transference of *Merycodus* to the Cervidæ, replying in detail to the points brought forward in my paper of 1904 and making, without question, a strong case for his conclusion.

His main argument is that the existence of a burr in the *Merycodus* antlers is infallible proof that they were deciduous; that the presence of deciduous antlers is the fundamental and essential character of the Cervidæ; that it is not likely that so peculiar a character could be exactly duplicated by parallelism; that many of the characters that I cited as Antilocaprine are paralleled more or less among the Cervidæ, and of some others he is doubtful whether the described specimen¹ demonstrates the characters claimed. He does not see any real correspondence between the deciduous forked horn sheath of *Antilocapra* with its permanent core, and the deciduous antler of *Merycodus*, corresponding not to the sheath but to the core of *Antilocapra*.

These strictures are warranted, at least in part, as applied to the very inadequate presentation of the evidence in my paper of 1904. There was, however, even then a good deal that I did not make clear, and much more can now be shown, against reference of the genus to the Cervidæ and in favor of its reference to the Antilocapridæ as a separate family.

I.—Character of the Antlers. There are half-a-dozen skulls in the American Museum collections, complete enough to show the association of antlers with teeth; and many more "frontlets" or crania which lack the teeth. Several hundreds of upper or lower jaws and numerous unassociated antlers, or parts thereof, are also in our collections. These serve as basis for the following characterization.

(a.) Antlers on both male and female, not in the young. This is probable from the fact that all our crania and frontlets have antlers. A young skull in the Carnegie Museum collections (type of "*Cosoryx agilis*" Douglass) lacks them but still retains most of the milk teeth.

(b.) Antlers are not more than once forked, except in one species or group of species. I have seen only three or four specimens of 3-tined antlers besides those figured by Cope.

(c.) The forking is not a progressive character, so far as the record shows. All our Pliocene specimens are single-forked. The type of *M. osborni* (Upper Miocene) is an old individual, but others of almost or quite as great wear in the molars have a simple two-tined antler.

¹He is evidently under the impression that the *M. osborni* skeleton is the only known specimen.

(d.) The "antlers" are unlike those of the Cervidæ in their smooth hard surface. They differ equally from the soft-surfaced horn-cores of Bovidæ, or from the rough surface of giraffid horns, but are quite exactly like the horn-cores of Antilocapridæ, save that they are oval and forked and provided with a burr, instead of being flattened and unforked and with no burr. They have some resemblance also to the antlers of deer "in the velvet" and do not differ so much from brocket antlers as from the larger and more complex types.

(e.) The burr at the base of the beam may be single, double or triple, in two cases quadruple. It is very easily broken off and leaves no perceptible scar beneath it, the surface of beam and stock being identical in character. The burr is the sole basis for the statement that "antlers" were deciduous. As a matter of fact they are NEVER FOUND BROKEN OFF AT THE BURR. The fossil specimens are broken off frequently at the base of the stock, some of the orbit going with the antler and breaking off as it is knocked about. Or the antler breaks off anywhere along stock or beam. But a clean break at the burr I have never seen. This is a sharp contrast to the true fossil deer, among which the antler is customarily found broken off at the burr.

These data concerning the antler might seem open to two possible interpretations. Either the antler was NOT DECIDUOUS, but covered during life with a velvet or with a horny casing which split or peeled off periodically but not until a new protective casing had formed within it, the burr then representing the seasonal stoppage of growth and lime supply after the new growth of horn and horn-case had been completed. Or the habits of the *Merycodus* were such that its remains were never buried in stream-valley deposits except during the time that the antlers were in the velvet. It would seem a tenable hypothesis that the animal always retired to the mountains in late summer and autumn, drinking from the mountain brooks and never approaching the muddy streams of the plains except in the spring when the antlers were full-grown but still in the velvet.¹ On the theory that the *Merycodus* antlers were deciduous like those of the Cervidæ this hypothesis would explain the fact that the antlers are always found fossil in this condition, never rugose, and never shed. But it is very difficult under this supposition to explain the peculiar character of the three or four successive burrs all loosely attached to a beam continuous with the stock. In the deer the burr breaks off with the shed antler and a new one is formed at the base of the

¹This was, in fact, a suggestion made to me by Mr. Madison Grant when we were discussing the matter in 1902.

beam when the new antler ceases its growth. Obviously a multiple burr could not normally occur with a deciduous antler. But in *Merycodus* the multiple burr is certainly a normal character. It appears to me far more reasonable, therefore, to conclude that the bony horn-cores were not deciduous.¹

(f.) The horns are supraorbital (when the basicranial axis is horizontal) as in *Antilocapra* and many antelopes. In Cervidæ the antlers are more posterior in position and the stock is usually plastered on to the side of the brain-case to some extent. In the larger and more progressive Bovidæ the horns move backward during the growth of the individual and in primitive and juvenile deer the antler begins almost supraorbital, so that *Merycodus* may be said merely to retain the primitive relations of all Pecora in this respect.

II.—Characters of the Skull. The bending down of the basifacial on the basicranial axis is a progressive character developed to a marked extent in most Bovidæ, to a lesser extent in some Cervidæ. In *Merycodus* and *Antilocapra* it is strongly marked. This is a character that might very readily be the result of parallelism and it is not advisable to attach too much weight to it.

III.—Characters of the Teeth. The real weight of argument for relationship lies in the teeth. The molars are hypsodont, progressively so from first to third. They increase notably in size from first to third. The last upper molar tends (progressively) to establish a third lobe, and the last lower molar a fourth lobe. This is incipient in the Middle Miocene *Merycodus necatus*, variable in the Upper Miocene *M. necatus sabulonis*, established in the Lower Pliocene *M. altidens*, well established in *Capromeryx* and *Antilocapra* of the Pleistocene. The teeth have smooth surfaces and the molars no accessory cusps, resembling *Antilocapra*, Camelidæ and most Bovidæ, unlike Cervidæ or Giraffidæ. The comparatively small simple and hypsodont premolars have the primitive pecoran construction of the crests—three inner transverse crests, one posterior outer one—from which *Antilocapra* has departed less than either Cervidæ, Bovidæ or Giraffidæ. The construction in *Merycodus* is very close to that of *Blastomeryx*; *Leptomeryx* of the Oligocene presents a more primitive stage, as I have elsewhere attempted to show. There is, however, a certain angularity of outline and proportion, and relative reduction of the anterior premolars, in which *Merycodus* foreshadows *Capromeryx* and *Antilocapra*.

¹Scott in 1890, Bull. Mus. Comp. Zoöl., XX, p. 84, observes that the burr of *Cosoryx* "can hardly be regarded as evidence that the antler was deciduous."

The antilocaprid characters of the teeth in *Merycodus* are far more than mere hypsodonty of the molars. But they must clearly be interpreted in light of the fact that this is a Miocene genus and must be compared with other Miocene genera in order to get a fair concept of its relative position in the phylogenetic tree. The primitive construction of the premolars is shared by *Blastomeryx*, *Dremotherium* and other early Cervidæ, as well as by the most primitive of the antelopes and giraffes. On the other hand, *Merycodus* lacks two characteristic Cervid features, the rugose enamel and the intercalary basal pillars, already assumed by *Blastomeryx* and the *Palæomeryx* group and present in all Cervidæ and Giraffidæ, although almost lost in some modern deer. It has also already assumed certain specialized antilocaprid characters, the relative reduction of the premolars, especially the anterior ones, the increase in size and hypsodonty of the posterior molars, the third cusp on m^3 and the fourth cusp on m_3 , progressively developed in the later species.

There are several deer and small antelopes that have teeth quite as hypsodont as *Merycodus* but they do not assume the other characters cited, which are to be found united only in *Antilocapra*, although some of them occur sporadically among other ruminants. Thus *Rangifer* is what Doctor Winge asserts *Merycodus* to be—"merely a deer which has developed hypsodont teeth." But *Rangifer* retains all the Cervid characters in the teeth—the rugose enamel, the basal pillars on the molars, construction of the heel of m_3 , the large size, broadly oval form, and particulars of construction of the premolars; and so do various other more or less hypsodont Cervidæ. *Merycodus* has none of them. The true antelopes include various hypsodont types, some of which approach *Merycodus* more nearly. The gazelle has the smooth molars with no basal cusps and about the same degree of hypsodonty. But the molars do not show the characteristic increase from first to third nor the tendency to form an extra posterior lobe¹; the premolars do not show the tendency toward a trigonal outline, the relative reduction and simplicity of the anterior premolars nor some other constructional peculiarities of detail. The several characters of the *Merycodus* teeth are seen combined in *Antilocapra* alone; they are not due to its hypsodonty nor explainable as parallelism.

For these reasons I have hitherto regarded the teeth of *Merycodus* as proving its affinity to *Antilocapra*, in spite of its supposedly cervid deciduous antlers². These constituted, after all, one character which,

¹This is shown, however, in some true antelopes.

²As stated by Cope in 1877 and Scott in 1890 and accepted by all subsequent writers.

remarkable as it was, could be explained as parallelism within the same large group. The teeth, on the other hand, showed a dozen or so non-correlated characters of affinity to *Antilocapra* and it was incredible that simultaneous parallelism could account for all of these. The antilopid or antilocaprid affinity was further confirmed by the sharp downward angulation of the basifacial axis and the supraorbital position of the horn, characters not peculiar to the antilopoid division but characteristic of it as opposed to the cerviformia. The extreme reduction of the lateral digits, greater than among Cervidæ and less than in *Antilocapra* or most true antelopes, again confirmed this view of its relationship; while the grooved back of the metapodials, to which Winge attaches great importance, was quite obviously a primitive character, both in theory and from the record, and is shown by all Miocene ruminants of any group at all, and retained by some antelopes as well as by most deer.

With many authors, however, the evidence of the antlers outweighed everything else. But if, as now appears, the "antlers" were NOT deciduous but their sheath periodically renewed as in *Antilocapra*, it does not appear that there is any evidence left for cervid affinities. All the characters conform in indicating antilocaprid relationship. On the question of whether or not the genus is a direct or approximate ancestor of *Antilocapra*, it is not necessary to enter here.

BOVIDÆ

NEOTRAGOCERUS

This genus was based upon a horn-core, with which were provisionally associated certain brachyodont, smooth and simple antilopine upper molars. It was tentatively referred to the Tragocerine group but its affinities cannot be settled until the skull is known, or at least some positive association of horn and dentition. Dr. Joleaud in a recent publication has referred it to the Hippotragine group, which may perhaps prove to be correct; and in support of this reference it may be noted that two incomplete teeth in the 1918 collection have a rather marked resemblance to those of *Hippotragus* and it may be that these should be referred to *Neotragocerus* and the dentition provisionally associated with it in 1909 really belongs to *Craniocerus* or some undescribed genus.

It is at least equally probable that neither *Neotragocerus* nor *Craniocerus* have any near relationship with any of the Old World antelopes with which the imperfection of our knowledge has suggested comparison, and to discuss palæogeographic theories based upon such flimsy

evidence appears to me an utter waste of time. The collections from the Chinese Pliocene now being studied by Professor Wiman of Upsala, together with further collections from the Tertiary of China now being made by the Chinese Geological Survey and The American Museum of Natural History, will, one may hope, provide really sound and adequate evidence as to the Tertiary distribution and migrations of the several groups of antelopes, and more complete and better associated American



Fig. 61. *Testudo angusticeps*; skull, natural size, top view. Lower Snake Creek beds, *M. paniensis* zone.

material may give definite and certain data as to the affinities and derivation of the New World genera. Until these data are at hand such positive and detailed conclusions as Dr. Joleaud has expressed are merely proof that he does not appreciate the inadequacy of the evidence cited in support of his theories or the amount and gravity of the objections that stand in their way.

CHELONIA

***Platypeltis miocænus*, new species**

TYPE.—No. 6298, carapace lacking the nuchal bone, from *paniensis* zone, Sinclair draw.

CHARACTERS.—Shell comparatively narrow, as in *P. ferox*. Vacuity between nuchal, anterior neural and anterior costal, as in *P. leucopotamica*.



Fig. 62. *Platypeltis miocænus*; carapace, three-fifths natural size. Lower Snake Creek beds, *M. paniensis* zone.

This is the first carapace of a soft-shell turtle to be reported from the American later Tertiary.

***Chelydrops stricta*, new genus and species**

TYPE.—No. 6297, an incomplete skull from the *paniensis* zone, Sinclair draw.

CHARACTERS.—Size of modern snapping turtle but skull considerably narrower, muzzle more pointed and decurved; a central ridge on the jaw-plate, much as in



Fig. 63. *Chelydrops stricta*; front of skull, side and palatal view, natural size. Type specimen, No. 6297, Snake Creek beds, *M. paniensis* zone.

Testudo. A much smaller skull, No. 6296, has a very sharply pointed and decurved beak and about the same relative width of the jaw.

This appears to be the first record of the snapping turtle from the Tertiary. It has been recorded by Doctor Hay from the Pleistocene upon fragments of the carapace. It is probable that the failure to recognize it hitherto in the later Tertiary formations is due not to its absence but to the uncharacteristic form of its shell elements and the tendency of the shell to break up into separate parts, which have been mistaken for the ubiquitous and unvalued tortoise fragments.

***Testudo orthopygia angusticeps*, new mutant**

TYPE.—No. 6295, a skull with greater part of carapace and plastron doubtfully associated, from the *Merychippus primus* zone, Stonehouse draw.

CHARACTERS.—Skull somewhat narrower than in most large tortoises of the Miocene and Pliocene in which the skull is known; slightly narrower than in *T. osborniana*, with orbits facing more laterally, interorbital space wider, arches somewhat more massive. The shell attains a large size, up to 750 mm. according to our estimates, the width of the ? type shell being 450 mm.

Comparison of the skulls of *T. thomsoni* of the White River with the present species, *T. osborniana* of the Pawnee Creek, *T. gilberti* (? = *orthopygia*) of the Republican River, and some large modern tortoises, shows apparently a progressive lightening of the skull, expansion of the arches forward and upward shift of the direction of the eyes, etc. Our material is not adequate to test the validity of this apparent progress. I venture to remark that a more careful search for skulls of extinct chelonians, and less reliance upon the characters of the carapace and plastron might perhaps aid in clearing up the real affinities of both fossil and recent members of the order. A classification of mammals based primarily upon the number and relations of the ribs and taking no serious account of the skull would probably be as unsatisfactory as are the current classifications of fossil chelonians.

***Testudo orthopygia* Cope**

An incomplete skull, many parts of the carapace and plastron from the Lower Snake Creek beds are referred to Cope's species, of which the type is from the Republican River beds. Specimens range from size approximately equal to the type shell, A. M. N. H. No. 6108, down to six inches in length. None of the shells agree at all closely either with the type or with each other, but they are somewhat nearer, on the whole, to *orthopygia* than to any of the numerous "species" of *Testudo* that Doctor Hay has described and illustrated in his monograph.

Article III.—THE MARINE ORNITHOLOGY OF THE CAPE VERDE ISLANDS, WITH A LIST OF ALL THE BIRDS OF THE ARCHIPELAGO

BY ROBERT CUSHMAN MURPHY

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INTRODUCTION

The present paper is an indirect result of a brief visit which the writer made to the Cape Verde Islands in September 1912. It is more immediately linked, however, with a collecting trip undertaken during part of the spring and summer of 1922 by Mr. José Gonçalves Correia, of New Bedford, Mass., whose specimens, numbering some three hundred skins of twenty species, have all been received by The American Museum of Natural History. As Correia's predominant object was to acquire adequate series of water birds, the terrestrial species of the Cape Verdes are but scantily represented in his collection, which is supplemented, to a certain extent, by a small number of specimens obtained by the writer in 1912.

Notwithstanding the relatively limited material available for study, it has been thought advisable to include within this paper a systematic list of all the birds known from the Cape Verde Islands. The latest faunal contribution is that of Salvadori (1899). Not only have additions to the avifauna been made since that date, but also forms new to science, including several endemic races, have been described. Moreover, numerous nomenclatural changes made necessary because of the researches of Hartert ('Vögel der paläarktischen Fauna,' 1910-22) and other workers increase the need for a new list.

During the course of his study, the writer was materially assisted by the following colleagues, to each of whom he extends his hearty thanks: Dr. Joseph Bequaert, of Harvard Medical School, who translated a

Dutch paper by Keulemans; Dr. Henry B. Bigelow, of the Museum of Comparative Zoölogy, who read the text of the oceanographic discussion and made many useful suggestions; Dr. James P. Chapin, of The American Museum of Natural History, whose critical opinion of African taxonomic and faunal relationships was of constant aid; Dr. Frank E. Lutz, also of the American Museum, who suggested and helped to work out the statistical treatment of *Calonectris kuhli edwardsi*; and Mr. Paul Vanorden Shaw, who read all of Correia's Portuguese field notes and dictated an English translation.

HISTORICAL SKETCH OF CAPE VERDE ORNITHOLOGY

Although Barboza du Bocage (1898) refers to bird collecting as early as the year 1784, the science of ornithology in the Cape Verde Islands may be said to date from January 1832, when the 'Beagle,' with Charles Darwin on board, visited São Thiago (St. Jago). The birds obtained by Darwin and the naturalists associated with him were subsequently reported upon by Gould.

In 1856 Carl Bolle published the first general account of Cape Verde ornithology, based upon his visit to the islands four years earlier.

In 1865, Dohrn, of Berlin, collected at several of the islands. His companion and assistant was a young Hollander, J. G. Keulemans, who subsequently attained world-wide fame as one of the most successful portrayers of birds. Keulemans' field notes of the Cape Verde trip were published in Dutch in 1866, five years in advance of the report of the leader. They give an excellent account of the life history of species which came under his notice, although Dohrn, perhaps somewhat piqued that the youthful artist and taxidermist should have burst into print ahead of the leisurely professor, states that Keulemans' article is untrustworthy as to the identification of the birds as well as in other respects.

During July and August, 1873, the 'Challenger' put into port at São Vicente and São Thiago, affording Moseley an opportunity to gather miscellaneous notes regarding the native birds ('Notes by a Naturalist on the 'Challenger,' 1879).

In 1883 Oustalet described the large shearwater which is the most important of the endemic water birds.

In 1897 Boyd Alexander, accompanied by a corps of assistants, visited all the islands of the group. His observations were published in two papers, which appeared in the *Ibis* during 1898. Alexander had evidently not familiarized himself with the earlier literature relating to

his chosen field, for his articles are characterized by faulty nomenclature, the omission of synonymic and bibliographic references, and by several unwarranted designations of supposedly new forms. He nevertheless discovered and described a remarkable species of lark (*Spizocorys razæ*), which is endemic, and by his energetic collecting he greatly extended the list of migratory birds known to occur on the islands. Moreover, his writings give by far the best record of the habits of Cape Verde birds, while his terse descriptions of the islands themselves, as well as of biotic conditions and the human inhabitants, possess a literary quality which give the author high rank among those who have published upon the natural history of the group.

In the same year the article by Barboza du Bocage made its appearance—a nominal list with a useful tabulation of vernacular names and insular habitats.

Salvadori's short but scholarly paper (1899) is based upon the collections and communications of Fea, who had traveled in the Cape Verdes during the previous year. Eleven birds were added to the known avifauna, one of these being a new subspecies of petrel (*Pterodroma mollis feæ*). Salvadori searched the writings of previous authorities, including several little-known Portuguese commentators, and he prefaced his discussion of each of the forty-seven species obtained by Fea with an exhaustive synonymy which rendered the paper indispensable to subsequent workers.

THE VISITS OF CORREIA AND THE AUTHOR

The writer's only opportunity to visit the Cape Verdes came during an expedition¹ to South Georgia made in the whaling brig 'Daisy,' under the joint auspices of the Brooklyn Museum and The American Museum of Natural History. On September 15, 1912, the welcome cry of "Land ho!" rang out from the masthead, and we soon made out the heights of Santo Antão, the first landfall since the vessel had passed Sombrero, West Indies, forty-five days before. At evening the brig stood off shore, but during the small hours of the next morning she bore again toward land.

A heavy mist lay along the windward side of the island, and we could at first make out only the western point of Santo Antão. Later, however, we saw that the cloud bank hung nearer the bottom of the land than the top, for far above the veil stretched the blue crest of the mountains. We approached the island from the northeast. Except for short

¹1914, Brooklyn Mus. Sci. Bull., II, No. 4.

periods in the early morning and at sunset, clouds and mist hid the lower face of the hills, and it seemed to be raining in every valley. In a gorge west of Punto do Sol two slender cascades, several hundred feet in length, were streaming from high ledges. A thin coating of bice-green foliage lay on the slopes, although the bare rock showed through in most places. A number of villages, consisting of stone buildings with tile roofs, stood out against a background of verdant terraces and almost perpendicular garden plots. The surf broke furiously upon beachless shorelines, while from the foam basaltic dikes rose like buttresses against the steeps above.

The well-watered appearance of Santo Antão hardly prepared a visitor for the desolation of the neighboring island of São Vicente, which, in the words of the Yankee whalemén, is "hell with the fires burnt out." Bird Rock with its surmounting lighthouse, in the harbor of Porto Grande, was visible from afar. Behind it naked, brick-red hills were piled up indiscriminately, with sharply marked laminæ lying at every angle, and all ending in peaked and crumpled summits. The strength and irrationality of attachment to a homeland were brought forcibly to the writer's attention when this forlorn island first came into view, for several native sons from the 'Daisy's' forecastle, who had beheld without emotion some of the world's fairest spots, began to dance with patriotic joy.

Mr. Correia was a member of the 'Daisy's' crew at this time, and during our short stay at São Vicente he and the writer lost no opportunity to collect birds in the environs of Porto Grande.

Through the efforts of the American consular agent, Mr. J. B. Guimaraes, a permit was issued which granted us permission to shoot any species except quail. The latter, we were informed, had just begun to breed with the advent of the so-called rainy season and were considered worthy of protection. It should be gratefully noted here that Mr. Guimaraes continued his good offices for the American Museum ten years later when, on the occasion of Correia's second visit, he extended every courtesy within his power.

São Vicente was the 'Daisy's' only port of call in the Cape Verdes. On the day after our departure, however, we sailed close by Brava and saw the smoking cone of Fogo (9760 feet) looming up to eastward. The interest aroused by the brief visit, and particularly by the numbers of Tubinares, Steganopodes, and other sea birds observed in the waters about the archipelago, led long afterwards to the expedition entrusted to Correia.



Fig. 1. Sketch Map of the Cape Verde Islands.

The field work undertaken by Correia in 1922 followed a stay of some months at his boyhood home in Fayal, Azores. He arrived at São Vicente, Cape Verdes, on May 4, and during the balance of the month paid visits to the neighboring islands of Branco, Razo, and Santa Luzia. Leaving São Vicente again on June 1, he made a voyage in a sailing vessel to Brava, calling en route at São Thiago and Fogo. On June 14 he crossed from Brava to the Rombos Islets, where he remained until July 4. Ten days more were then spent in collecting at Brava, and an additional ten days at São Vicente, before he sailed on July 26 for the Canary Islands.

Mr. Correia observed the breeding of most of the native sea birds and obtained the eggs and young of several species. He believes, nevertheless, that he reached the Cape Verdes too late to take advantage of the height of the nesting season, which, among the petrels at least, occurs in March. Correia's field journal has proved of no less importance than his specimens, and in the following pages the more valuable portions of the notes are quoted in freely translated form. His text has been somewhat abbreviated, but the sense is unchanged. Even in two or three instances in which certain statements seem to rest upon inconclusive observation, the testimony is given as originally recorded.

THE GEOGRAPHIC ENVIRONMENT

The Cape Verde group lies from 313 to 475 nautical miles from the west African coast between the parallels of $14^{\circ} 46' N.$ and $17^{\circ} 13' N.$, and the meridians of $22^{\circ} 40' W.$ and $25^{\circ} 22' W.$ The total land area is a little under 1500 square miles. The islands, with the exception of certain sedimentary rocks on Maio, are of submarine volcanic origin and of middle Tertiary age.¹ Fogo alone still has an active crater, which has been in eruption as recently as 1847.

Like the Canary Islands, the Cape Verdes rest upon the broad and deeply submerged shelf that extends from the African coast, the 2000-fathom line lying entirely to westward of both archipelagoes. The Cape Verdes comprise ten main islands and the uninhabited islets of Branco, Razo, and the Rombos or Seccos Rocks north of Brava. Santa Luzia, Razo, and Branco, which are situated between São Vicente and São Nicolau, are often called collectively the Desertas. In maritime terminology, the southerly islands of Maio, São Thiago (St. Jago, Santiago), Fogo, and Brava, constitute the leeward (*sotovento*) portion of the archipelago; the other six, namely Santo Antão (St. Antonio), São Vicente (St. Vincent), Santa Luzia, São Nicolau (St. Nicholas), Sal, and Boa-Vista, are the windward (*barlovento*) group. An orogenic classification would be somewhat different, for the islands fall into three natural subdivisions, each composed of rocks emerging from a common platform and each separated from the others by deep channels. Thus Santo Antão, São Vicente, Santa Luzia, Branco, Razo, and São Nicolau, rise from one bank; Sal, Boa-Vista, Maio, and São Thiago form a like aggregation; and Fogo and Brava, with the Rombos Islets, make the third. As might

¹Late Tertiary or recent changes in level have taken place along many shorelines of the islands. These account for beds of marine deposits such as those near Porto Praia described by Wilkes (1845, 'Nar. U. S. Expl. Exp. 1838-42,' I, p. 30).

be expected in a volcanic group, the meteorological conditions, as determined by the prevailing wind, have apparently exercised a greater influence upon the distribution of the insular life than have the geologic interrelationships of the land areas.

It would be out of place to describe in detail the various islands of the Cape Verdes,¹ but such features of the lesser known members as have a relation to the marine bird life will be of interest.

In the northern group, Santa Luzia has an area of ten square miles and an altitude of 1209 feet. The coast is mainly unapproachable, but there is a harbor on the southwest. Branco is two miles long by a half mile in breadth. Razo, sometimes called Rodonda from its outline, lies three miles southeast of Branco, and is about five miles in circuit.

Alexander (1898, pp. 105, 109) visited these islands during the months of April and May, and describes them as follows:

“The small islands known as the Desertas are three in number: Raza, Branca, and Santa Luzia. The two former, devoid of water, are uninhabited; no hostile influence coming to mar the peace of the many sea-birds that have made them their home, save perhaps at random times when fisherfolk land and employ the day in catching fish.

“Raza was the first island we visited, and all the time we remained on it the schooner was obliged to beat backwards and forwards, there being no anchorage. Landing is effected with difficulty (at times being well nigh impossible), and only then on the south side, upon a broad band of low flat rock. This island possesses an area of about three square miles, the larger portion of which is flat, strewn, however, with stones of all sizes, the boulders in many instances being undermined by Shearwaters; but here and there, amid this expanse of stones, there are patches of smooth ground, toned with fine dead grass, and with a creeping plant bearing a prickly fruit (*Tribulus cistoides*). On the north side, hills descend abruptly to the sea; while the low flat ground on the south is terminated by an almost perpendicular face of rock, at the most thirty feet in height, and rent with wide fissures and jagged scars.

“Branca is nothing more than a small irregular chain of lofty, craggy hills, rising up from the sea with extraordinary abruptness on its north side, while about halfway down its height this chain has almost a glacis-like slope down to the sea. This slope is honeycombed by Petrels. We found the White-breasted Petrel (*Pelagodroma marina*), *Puffinus*

¹A recent authoritative account of the archipelago is the following: ‘Cape Verde Islands.’ Handbooks Prepared under the Direction of the Historical Section of the Foreign Office, No. 117. London, H. M. Stationery Office, 1920.

assimilis, and *Oceanodroma cryptoleucura* [= *castro*] breeding, all having young. *Puffinus mariæ* [= *edwardsi*] also inhabits the island. From several Petrels-holes we pulled out Cocteau's skinks, but, there being few of these lizards, the Petrels have made the island their home. There is not a doubt that Raza was also a breeding-place before the skinks became numerous there, for we found many disused Petrel's holes on that island."

The following is extracted from Correia's field journal:

Santa Luzia has served in the past as a whaling station, and the ruins of sperm try-works still stand there. The only occupied dwelling on the island is the home of a family from São Nicolau who have charge of cattle and goats. These residents rely upon the fishermen from São Vicente for their communication with the outside world.

Since there is practically no rainfall, Santa Luzia produces no crops. The only drinking water comes from one small spring of fresh water on the eastern shore and two brackish wells. The island is therefore exceptionally barren and gloomy, and the vegetation which the animals need can be found only in the cloud-zone of the heights.

Only to the fishermen is Santa Luzia of great value, for the straits toward São Vicente and Branco teem with fish. However, fishing can be conducted with success only for about an hour during the flood and ebb, respectively, for the tidal currents about the island are extraordinarily strong and treacherous.

Only two sea birds, the booby and the white heron, appear to inhabit Santa Luzia in large numbers, and of other kinds I noted none but sparrows, kestrels, and curlews.

Branco, meaning white, lies next toward the southeast, and takes its name from extensive areas of a white mineral in the rock at the northern end, and perhaps also because of a white strip of sand on the western side. Its hills rise to a height of five hundred feet or thereabouts. The western side is like a wall, but one may land at the north point or at several places along the easterly coast. At the southern point is a cove about a hundred yards in depth which is much used by fishermen. At the very margin of the sea there are here two springs which are exposed only at low tide. The water is not particularly palatable, but one must drink it or nothing, and the fishermen land when opportunity offers to fill their kegs and canteens.

Branco is a place of strong winds, tumultuous seas, and poor anchorages. There is no shelter whatsoever when windstorms whip the waves over the narrow strands and rocky points, so the fishermen usually make their visits short.

Numerous petrels and shearwaters nest in the hills of Branco, according to the fishermen, but I made no collections here.

A few miles farther southeastward is Razo, circular in form, with a low tableland at the northern end, and rock-strewn coast to southward. There is no sandy beach and no fresh water. The name Razo, meaning shallow, refers to the fact that the sea sometimes sweeps over large parts of the island. It is possible to land at two places on the northern coast, and groups of fishermen from São Vicente and São Nicolau sometimes go there with food and water for a week's stay, returning with fish which they have dried.

To Razo great numbers of maritime birds come to breed, and the human visitors often kill more birds than fish. I saw altogether fourteen species of birds on the island, namely, booby, tropic bird, large shearwater, small shearwater, Mother Carey's chicken (*Oceanodroma*), black petrel (*Bulweria*), turnstone, white heron, osprey, kestrel, swallow, raven, lark and sparrow.

North of Brava are the six Rombos Islets, a second great center of marine bird life. Correia writes:

These islands extend from east to west for about five miles. The first on the east is known as Rombo, Cima, or Ilheu de Fora. It is close to three miles round, but very narrow—hardly more than a hundred yards at the widest point. At the southwestern end is a high peak. This is the home of the boobies, the birds which produce guano used by the inhabitants of Brava on their intensively cultivated fields. The guano of Cima has gone even farther, for in past years vessels from both Lisbon and the United States have loaded their holds here.

There are thousands of boobies on this island, although the fishermen slaughter great numbers for food. Besides these and other birds, there are sea turtles, crabs, and many kinds of shell-fish. The vegetable productions include grasses, small shrubs, and gourds. There is no fresh water, and the strength of the trade wind over the generally flat surface makes life uncomfortable.

The next islet is called Lesser Rombo, and is only three hundred feet distant in a northwesterly direction. Hereabouts are other small rocks called Seccos, all without vegetation and inhabited by numbers of boobies and tropic birds.

At the western end of the series is Baixo, Ilheu de Dentro or Ilheu Grande, which was once a port of much consequence to American whalers recruiting at Brava. Here many foreign sailors, including Yankees, have been buried. The island is about two miles in diameter, nearly circular, and forms mostly a uniform plateau, but with a high peak toward the southeastern point. No birds live upon it. Formerly it was cultivated by a resident family, but lack of rains for several successive years caused them to abandon the island. The ruins of the home and cistern are all that remain, yet in spite of the dryness, much of the ground is covered with grass and other green vegetation.

Alexander (1898, pp. 94, 95) writes of this same island:

"Its general character is flat, save for a lofty hill of a sugarloaf shape that rises up about its centre, while creeks and small bays make indentations along the coast-line. In many places its surface is strewn with ironstone, while there are several creeks that hold nickel and copper.

"A few wild goats inhabit the island, while the only birds we came across were a solitary Vulture and a Kestrel. Petrels used to breed here in numbers until they were driven away by the descendants of a pair of cats brought over by the goatherd."

The birds which Correia observed on Cima or Greater Rombo were the following: booby, tropic bird, small shearwater, black petrel (*Bulweria*), Mother Carey's chicken (*Oceanodroma*), gray petrel (*Pelagodroma*), white heron, Egyptian vulture, osprey, kestrel, raven, sparrow, and blackcap (?).

General references to the aridity of the climate of the Cape Verdes should not lead to the supposition that all of the islands lack vegetation and diversified, even bucolic, scenery. Alexander (1898, p. 90), for

example, has given the following cheerful picture of Brava, which has an area of but 22 square miles and a maximum altitude of 3609 feet:

“Brava is the smallest inhabited island of the whole group—about six miles long and four broad—and also, in proportion, the most thickly populated. Being very mountainous, volcanic in nature, and bare of woodgrowth, there is hardly a stretch of tableland on the whole island; the coast is steep and rugged—no shore-line to speak of, except for a short length of low-lying rock near the harbour. Wherever the hillsides are climbable every inch of ground is cultivated, being either sown with maize or planted with yams, while in the valleys there are small sugar- and coffee-plantations, orange-groves, etc. The harbour is small, but ships of considerable size can anchor within a few yards of the steep volcanic-looking cliffs. Three miles inland from the harbour, Povação, the principal town, is situated. A fine paved road leads up to it, but is so steep in places that it becomes well-nigh impossible to climb it either on horseback or on donkeys. In the larger valleys monkeys abound, doing much havoc among the sugar-cane.”

Again, Moseley, who was assuredly in a position to judge fairly, considered the Santo Domingo Valley of São Thiago one of the finest of all mountain valleys.¹ Santo Antão, which is still perhaps the least known member of the group, contains many regions of notable beauty, and is, moreover, more than locally famous for its fruits and other agricultural products, being one of a large number of tropical localities credited with producing the “world’s best oranges.” The island is said to have numerous areas of woodland at high altitudes. Its ruggedness and general inaccessibility are indicated, however, by a Portuguese proverb—“To be dashed to pieces on the rocks is a natural death in Santo Antão.”

The flora of the Cape Verdes is markedly Sudanese in character, most of the indigenous plants being common to the neighboring African littoral. Xerophilous types are, naturally, abundant. Notable among the unusual plant forms is the now rare dragon tree (*Dracæna Draco*), which is peculiar to the Cape Verdes, the Canaries, and Madeira. Tropical vegetation from America and the Orient, and European temperate zone forms, are thoroughly established on the insular lowlands and mountain tops, respectively. There are apparently no native mammals, but boars and African monkeys seem to have been introduced into the southerly islands as early as the fifteenth century. The reptiles, which include several endemic species, are all Ethiopian types.

¹ Notes by a Naturalist on the ‘Challenger,’ 1879, p. 64.

OCEANOGRAPHY AND CLIMATE

The Cape Verdes lie midway in the course of the northeast trade wind, and many floral and faunal characteristics, as well as the climate, are determined by the fact that the islands are to leeward of relatively cool ocean waters. The upper layers of the Atlantic about the group, and *pari passu* all forms of marine life, are materially affected by the southward-flowing Canary Current, which, to northeastward and nearer the shores of Africa, is marked by continuous upwelling of water from lower strata. South of the islands, as well as to westward or off shore, the average temperature of the ocean surface becomes warmer, a condition which obtains as far as equatorial latitudes, where the cooling effect of the Agulhas or West African Current can be observed. The data in Table 1 indicate that throughout the year the surface of the ocean within a five-degree rectangle on the northeastern side of the Cape Verdes is from 2° F. to 6° F. cooler than that within an equal area immediately southwest of the archipelago. The difference is most pronounced during periods of strong trade winds, and least between August and November. Water temperatures along a line drawn northeastward from the islands continue to decrease steadily as the continental coast is approached.

	Average Surface Temperatures	
	5-degree square N. E. of C. V. I.	5-degree Square S. W. of C. V. I.
January	70°F.	76°F.
April	71	76
June	72	77
September	79	81
December	74	79

Table 1.—Normal surface temperatures for periods of five years in the ocean to the northeastward and southwestward, respectively, of the Cape Verde Islands. The number of observations for each 5-degree rectangle averages about 100. Data from the Meteorological Charts of the North Atlantic Ocean, published by the United States Weather Bureau.

According to the ‘North Atlantic Pilot’ of the United States Hydrographic Office, the Canary or North African Current sets toward the southwest in the vicinity of the Cape Verde Islands at a rate of from fifteen to twenty nautical miles a day, being most perceptible near the easterly isles of Sal, Boa-Vista, and Maio (cf. Fig. 2). This oceanic stream is a homologue of the California Current, and, for the same geo-

physical reasons which control the latter, the belt of littoral surface water which it cools is much broader¹ than that affected by the northward-flowing Agulhas Current, or by the Humboldt Current of Peru, which is a counterpart in the Western Hemisphere of the Agulhas Current. Therefore the Cape Verdes, despite their low latitude and their distance from the continent, lie barely south of the isotherm of 68° F. for the surface of the ocean during the coldest month. Owing to the influence of the Atlantic trade wind drift, and the resultant Gulf Stream, this same isotherm passes far to the northward of the West Indies and touches the eastern coast of America at a point approximately twelve degrees of latitude north of its position near the African coast.

In general, the boundaries of the breeding ranges of tropical sea birds are fixed by water temperatures rather than by atmospheric temperatures (although, as will be explained later, the relationship is not a direct one). A further comparison of conditions on the two sides of the North Atlantic may, therefore, throw light upon problems of distribution. Toward the eastern side of the ocean the sequential isotherms of both air and water spread widely apart from one another; in other words, the gradation of temperature is slight through long distances on the meridians. Toward the western shores, on the other hand, short distances along north-south lines yield a high gradient, so that at all seasons of the year the isotherms tend to crowd together. Because of the greater latent heat of water these facts are correlated with the phenomenon that at most points in the eastern subtropical and temperate North Atlantic the average temperature of the surface of the ocean is lower than that of the air; whereas in the western part the water is prevailingly warmer than the air. Examination of plotted isotherms of air and water extending from northwest Africa to the Caribbean region and southern North America will reveal these striking differences between the two sides of the Atlantic. They are not without significance when we consider that frigate birds (*Fregata*) and boobies (*Sula*) in-

¹The tangential friction of the wind drives the surface layer of the ocean before it, but, owing to the fact that the eastward linear velocity of the earth varies with latitude, the direction which the moving water tends to take is to the right of the line of impulse (if the locality is north of the equator).

The distance off shore of the zone of maximum upwelling, along seacoasts which have prevailingly parallel winds, depends, therefore, upon (1) the latitude, (2) the trend of the coastline, (3) the constancy of the wind, and (4) the configuration of the ocean bottom. The Agulhas and Humboldt Currents impinge against shorelines which project into their paths, and consequently the active upwelling of water, to replace surface layers driven off shore by the wind, occurs within three or four miles of the coast, and the belt of cool and heavy water on the shoreward side is relatively narrow. The California Current, on the contrary, draws away from a coast which trends to the east of south; the principal zone of upwelling is 70 miles from shore, and the belt of cooled water is extremely broad. In like manner, the northeast trade wind and the southward bend of the African coast at latitude 22° N., form a combination which produces a very broad belt of relatively cool water to the northeastward of the Cape Verde Islands.

The writer has discussed this whole subject, in so far as it applies to the western coasts of North and South America, in the *Geographical Review* for January 1923, pp. 64-85 (reference on pp. 76 and 77).

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean temperature	71.1	70.3	70.9	71.2	72.7	74.3	76.3	79.0	79.5	78.8	76.5	73.4	74.5° Fahr.
Mean daily maximum	75.4	74.8	75.7	75.7	77.2	79.0	81.5	84.0	84.4	83.5	81.1	77.9	79.2
Mean daily minimum	66.7	66.4	66.4	67.1	68.2	70.2	71.8	74.3	74.8	73.9	72.1	68.9	70.0
Mean of (absolute) extremes, max.	79.7	79.9	80.2	78.3	80.4	81.9	85.5	87.8	88.5	87.4	85.3	81.5	89.6
Mean of (absolute) extremes, min.	61.7	62.8	62.4	63.7	65.5	68.2	68.5	71.1	70.0	68.9	67.1	62.6	59.4
Mean relative humidity	70	71	69	71	71	73	73	78	76	76	72	71	73 %
Mean cloudiness	4.4	3.8	3.1	3.1	3.0	3.5	4.7	5.1	4.2	4.1	4.3	4.3	4.0
Average precipitation	0.16	0.08	0.04	0.04	0.00	0.00	0.31	2.01	2.32	1.46	0.55	0.55	7.52 Inches
Number of days with rain, average	1.9	0.7	0.7	0.5	0.0	0.1	1.5	6.3	4.2	2.7	1.5	1.9	22.0
Number of days with thunderstorm, average	0.4	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.3	0.2	0.1	2.5

Table 2.—Summary of meteorological observations made at São Vicente, Cape Verde Islands, during ten years (period not known).
 Data from the Meteorologische Zeitschrift, May, 1909, p. 232.

habit the Bahamas, and tropic birds (*Phaëthon*) even reach Bermuda, whereas all of these forms find at the Cape Verdes their northernmost breeding stations in the EASTERN Atlantic. To the oceanographic conditions we must ascribe the absence of such wide-ranging birds from the Canary Islands.

As regards atmospheric temperatures, the Cape Verde Islands lie well south of the annual isotherm of 68° F. The influence of the Canary Current is apparent, however, in the relatively cool summer weather that prevails at the group. For all of the islands the monthly means range between 70° F. and 80° F. during the course of the year. The winter climate (October to March) is therefore similar, so far as temperature is concerned, to that of the Greater Antilles, in the same latitude; but, owing to the effect of the trade wind blowing from a cool ocean, the average atmospheric temperatures of July and August are comparable rather with those of Norfolk, Virginia.

The Cape Verde Islands lie within the field of the North Atlantic anticyclonic center, and in their vicinity the trade wind blows pronouncedly from November to May. During the "rainy" season, August to October (the "sickly" or malarial season of São Nicolau, Fogo, etc.), the southern limit of the trade wind zone closely approaches the islands from the south, and at this period the prevailing circulation is frequently interrupted, severe southwest gales sometimes occurring.

Effective droughts of great length are experienced in many of the islands, and famines cause considerable loss of life at intervals of a few years. Conditions were serious for lack of water at São Vicente during Correia's visit in 1922. The lack of precipitation here and at several other members of the group is determined in part by the topography of islands to windward. Thus São Vicente, as has been previously inferred, is particularly arid and sterile because it is largely shut off from the moisture of the trade wind by the lofty ridge of Santo Antão. The same applies in a lesser degree to the southerly or leeward slope of Santo Antão itself. Three or more years without appreciable rainfall may pass at São Vicente, but when sporadic showers eventually reach the island, it is said to turn green as if by magic. During the period between July and November, the average barometric pressure at São Vicente is slightly lower (29.9–30 inches) than that of other months, and it seems likely that the bulk of its scanty rainfall is brought by winds proceeding from the warmer ocean to southward.

The easterly islands of the archipelago are, for somewhat different reasons, fully as dry as São Vicente. Alexander (1898, pp. 109, 110)

records his impressions of Sal and Boa-Vista, for example, in the following words:

"The greater portion of the island [Sal] is flat, with a loose stony soil, sandy in places and devoid of all tree-growth, while towards the interior it is bosomed with brown-looking semiglobular hills. Of the whole group this island is the poorest in the way of bird-life.

"The next island we visited was Boavista, which is nothing more than a sandy desert, with the exception of a few stone-strewn levels and several hills of considerable altitude. This desert of silver-white sand abounds in shallow hollows scooped out by the wind, and sand-dunes, the sides of which near the shore-line have been fashioned by the sea into high embankments, while in many places along the entire coast long narrow tongues of stony ground shoot out into the sea, making deep low-coasted bays. Clusters of tall gaunt-looking coconut-trees grow in many of the sand-dells, and about their trunks nestle banana plants with their large leaves torn into a thousand shreds by the wind, while on the flat expanses are clumps of lavender-bushes and scattered acacia-trees, stunted and ill-grown."

The marked aridity of these islands nearest Africa, which have no high windward neighbors to intercept their rainfall, is doubtless to be ascribed more directly to the effect of the Canary Current. Sal, Boa-Vista, and Maio are less mountainous than the western and southern islands, their highest altitudes not exceeding 1300 feet. The parts of the trade wind which cross these land areas have had their temperature lowered by traveling above waters in which active upwelling occurs even at a considerable distance from the continent. When such air reaches the heated, radiating surface of the barren islands, it expands and its saturation point is raised. The hills, unlike the ranges of Santo Antão (7400 feet) and São Thiago (5000 feet), are not sufficiently lofty or massive to cause adiabatic cooling to the stage of precipitation.

Like most other groups of high, isolated islands, the Cape Verdes are subject to sudden gusts and squalls, so that navigation in small boats is hazardous, as Correia learned on several occasions during his short visit. On the other hand, calms often prevail in the lee of the land even when strong winds are blowing over the open sea. The channels between the various islands are mostly free from obstruction, an exception being produced by the extensive Baixo de João Valente or João Leitão, a coral reef between Maio and Boa-Vista. Several of the straits, such as that between Santo Antão and São Vicente and those around Santa Luzia, have rapid tidal currents and dangerous rips. Finally, a

curious state of low visibility is produced at certain seasons by the harmattan, or dust-laden breeze from Africa. This condition is to be expected between December and February, when the winds often have a pronounced easterly slant. The coasts and mountains of the Cape Verdes are at such times so obscured by a reddish haze that to one on shipboard the first warning of the proximity of land is given by breakers on a still indiscernible shore. The air of the harmattan¹ is intensely drying, and the particles of dust not only veil the sun but, through their high conductivity, they also cause the days to be exceptionally hot and the nights exceptionally cool.

GEOGRAPHIC RELATIONSHIPS OF THE BIRDS

Alfred Russell Wallace (1876, pp. 214, 215) considered the affinities of the insects, land shells, and birds of the Cape Verde Islands and came to the conclusion that the archipelago had probably derived its fauna "from the desert and the Canaries to the northeast . . . rather than from the fertile and more truly Ethiopian districts of Senegal and Gambia to the east." He grants a mingling of the two faunas but states that the preponderance is with the Palæarctic rather than with the Ethiopian. Of the 15 species of breeding birds known to him, he considers 7 as Palæarctic, 3 as endemic but of Palæarctic affinities, and 3 as Ethiopian, the remaining 2 being introduced forms from the West African subregion. Wallace's data on Cape Verde Coleoptera still further bore out his belief, for he states that "out of 275 species 91 were found also in the Canaries and 81 in the Madeiran group; a wonderful amount of similarity when we consider the distance and isolation of these islands and their great diversity of climate and vegetation."

Insect life may perhaps be readily transported by trade wind and ocean current. Regardless of the affinities with the Mediterranean subregion shown by the Coleoptera, Bannerman (1920, pp. 560, 561) differs with Wallace and concludes that the ornis of the Cape Verde Islands is definitely Ethiopian. He writes:

"The Cape Verde Archipelago has very few connecting links with the Canaries, the only Resident birds common to both being the Spanish Sparrow, Madeiran Spectacled Warbler, Egyptian Vulture, Osprey, Courser, and Migratory Quail.² Ethiopian types prevail in the Cape Verde Islands, as is only to be expected, and this Archipelago cannot by any stretch of imagination be included in the Palæarctic region."

¹For an excellent description of this type of dust storm at Gran Canaria see Bannerman's 'The Canary Islands,' 1922, pp. 215, 216, and also Appendix A (pp. 321-327), in which the African source of the æolian material is discussed by W. C. Smith.

²The Cape Verde Island courser and quail have since been described as endemic races.

Neumann (1819, p. 235) also grouped the Cape Verde birds in such a manner as to show but three purely Palæarctic types, as against ten purely African and twenty neutral types. This author, however, made the mistake of including introduced species as well as pelagic birds in his reckoning.

In the writer's opinion, both Bannerman and Neumann have stressed the Ethiopian claims far too strongly. An analysis of the avifauna may prove of interest.

Of the 75 forms of birds recorded from the archipelago, 38 are residents and 37 are seasonal visitants from more or less distant breeding grounds. The latter group must be disregarded in a consideration of zoögeographical affinities. Three of the resident forms, namely, *Numida galeata*, *Columba livia*, and *Estrilda astrild*, have been introduced by man, leaving a balance of 35 species and subspecies, of which the following 15 or 16 are here treated as endemic:

- | | |
|--|---|
| 1. <i>Puffinus assimilis boydi</i> . | 9. <i>Tyto alba detorta</i> . |
| 2. <i>Calonectris kuhli edwardsi</i> . | 10. <i>Micropus unicolor alexandri</i> . |
| 3. ? <i>Fregata magnificens</i> (?) subsp. | 11. <i>Ammomanes phænicura cinctura</i> . |
| 4. <i>Buteo buteo bannermani</i> . | 12. <i>Spizocorys razæ</i> . |
| 5. <i>Cerchneis tinnuncula neglecta</i> . | 13. <i>Pyrrhulauda nigriceps</i> . |
| 6. <i>Coturnix coturnix inopinata</i> . | 14. <i>Calamocichla brevipennis</i> . |
| 7. <i>Cursorius cursor exsul</i> . | 15. <i>Corvus ruficollis ruficollis</i> . |
| 8. <i>Halcyon leucocephala acteon</i> . | 16. <i>Passer jagoensis</i> . |

From the list of 35 native birds, 9 marine species (6 Tubinares and the *Sula*, *Phaëthon*, and *Fregata*) must still be eliminated on the ground that they are representatives of wide-ranging, pelagic, and insular forms which have no value as indicators of the faunal regions of Wallace. This leaves the small residue of 26 species, which the writer would place in three categories, as follows:

1. PALÆARCTIC ELEMENT.—*Marmaronetta angustirostris*, *Buteo buteo bannermani*, *Milvus migrans migrans*, *Pandion haliaëtus haliaëtus*, *Charadrius alexandrinus alexandrinus*, *Sylvia atricapilla atricapilla*, *Sylvia conspicillata bella*, *Passer hispaniolensis hispaniolensis*. Total, 8 species.

2. ETHIOPIAN ELEMENT.—*Phalacrocorax carbo lucidus*, *Bubulcus ibis ibis*, *Halcyon leucocephala acteon*, *Spizocorys razæ*, *Pyrrhulauda nigriceps*, *Calamocichla brevipennis*, *Passer jagoensis*. Total, 7 species.

3. NEUTRAL ELEMENT.—*Egretta garzetta garzetta*, *Phænicopterus antiquorum*, *Neophron percnopterus percnopterus*, *Cerchneis tinnuncula neglecta*, *Coturnix coturnix inopinata*, *Cursorius cursor exsul*, *Tyto alba detorta*, *Micropus unicolor alexandri*, *Alæmon alaudipes alaudipes*,

Ammomanes phænicura cinctura, *Corvus ruficollis ruficollis*. Total, 11 species.

In explanation of the last and largest of these three groups, it may be said to comprise birds of five classes, namely: 1, those whose breeding ranges extend from areas north of the Mediterranean southward more or less into Africa (e.g. *Phænicopterus antiquorum*, *Neophron percnopterus*); 2, those which range even south of the forest belt in parts of Africa, but which breed also from southern Europe eastward into Asia (e. g., *Egretta garzetta*, which is resident in India and Ceylon); 3, those which are alike related to representative forms to northward and to southward (e. g., *Cursorius cursor exsul*, *Tyto perlata detorta*, the latter of which is a member of an almost cosmopolitan species); 4, those characteristic of the northerly part of the desert zone, some of which have close relatives in Egypt, Arabia, or southwestern Asia (e. g., *Alæmon alaudipes*, *Corvus ruficollis*); 5, those which may have the greater proportion of their congeners in South Africa, but which, nevertheless, show closest affinity with species found along the northern border of the Sahara (e. g., *Ammomanes phænicura cinctura*).

It would seem, therefore, that from an ornithologist's point of view the Cape Verdes can be stamped neither as Ethiopian nor as Palæarctic, though the latter region has perhaps a shade the better claim. The archipelago possesses rather a typical borderline or transition avifauna, in which "neutrals" predominate, and in which desert types occupy a conspicuous place.

According to our present very imperfect knowledge of Cape Verde birds, São Thiago has the largest number of resident species, viz. 29. Boa-Vista comes second, with 23, the record for the other islands being as follows: São Vicente and São Nicolau, 20; Brava, 19; Razo, 16; Santo Antão and the Rombos Islets, 13; Fogo, 9; Sal, 7; Branco, 6; Santa Luzia, 3; and Maio, 2. From Boa-Vista 17 species of winter visitors are also known; São Thiago has a list of but 8, and no other island more than 6.

Turning now to a consideration of the marine birds, an outstanding feature of the Cape Verde avifauna is the absence of Laridæ, particularly of terns. The archipelago doubtless lies in the migration route of certain northern species, and the writer, in fact, observed a flock of small terns feeding with boobies a few miles west of Brava on September 19, 1912. It appears sure, however, that the Cape Verdes lack a single resident species of this cosmopolitan family, a fact all the more remarkable when we make note of the abundance of noddies (*Anous* and *Mega-*

lopterus), sooty terns (*Sterna fuscata*), bridled terns (*Sterna anætheta*), and fairy terns (*Leucanous*) at one or another of the insular groups which lie toward the southeast, south, southwest, or west. Moreover, a north-temperate, circumpolar species, *Sterna hirundo*, breeds at the Canaries and Madeira to northwestward, while the Azores have in addition a native gull (*Larus fuscus atlantis*).

Why should the Cape Verde Islands share the brown booby and the tropic bird of the West Indies, Fernando Noronha, St. Paul's Rocks, Ascension, and the islands of the Gulf of Guinea, and yet lack the noddy and the sooty tern? Climatically and topographically the archipelago might well be occupied by such vast colonies of tropical terns as cover parts of Ascension or of islands in the Caribbean. What, then, is the nature of the invisible barriers which stand, for example, against *Anous stolidus* on the south and west, and against *Sterna hirundo* on the north?

To oceanographic factors we must look again for an explanation. A broad belt of ocean water divides the nesting latitudes of equatorial and Holarctic terns, and the cause of this separation is correlated with the fact that the surface water of the dividing belt is of too low mean temperature to be favorable to the former sea birds and of too high mean temperature for the latter. Keeping in mind the previous discussion of the subject (pp. 222-224), it will be seen that this belt is more southerly in position, as well as of greater latitudinal breadth, in the eastern Atlantic than in the western Atlantic. The Cape Verde Islands and Bermuda lie within the neutral zone; the Canaries and Cape Hatteras lie north of it; the Gulf of Guinea and the Bahamas lie south of it. The hiatus between the breeding ranges of *Anous stolidus* and *Sterna hirundo* is fifteen hundred geographic miles wide in the eastern Atlantic, and less than six hundred miles wide in the western Atlantic.

If we plot the mean surface temperatures of this ocean for the month of June, as in figure 2, the crowding together of the lines in the western Atlantic, which is equivalent to a narrowing of the zone, becomes apparent. Moreover, it will be observed that the isotherms of 70° F. and 80° F. practically coincide with the borders of the neutral ground between the ranges of tropical and north temperate terns.

It need not be surmised from the above that varying temperatures of ocean water, within small absolute limits, have a direct bearing upon the distribution of sea birds. The whole matter belongs to the sphere of marine ecology, and the chain of causal relationships may well be long and intricate. The factors are evidently highly specific in their action, for we have already seen that conditions true for certain tropical Laridæ

do not apply in the same degree to the Steganopodes. It is conceivable that the question has to do entirely with the geographical distribution of the food of the sea birds, although such a suggestion merely restates the problem. In the absence of exact knowledge about the food supply, we can say only that the ranges of the birds appear to be closely correlated with certain isotherms of surface temperature.

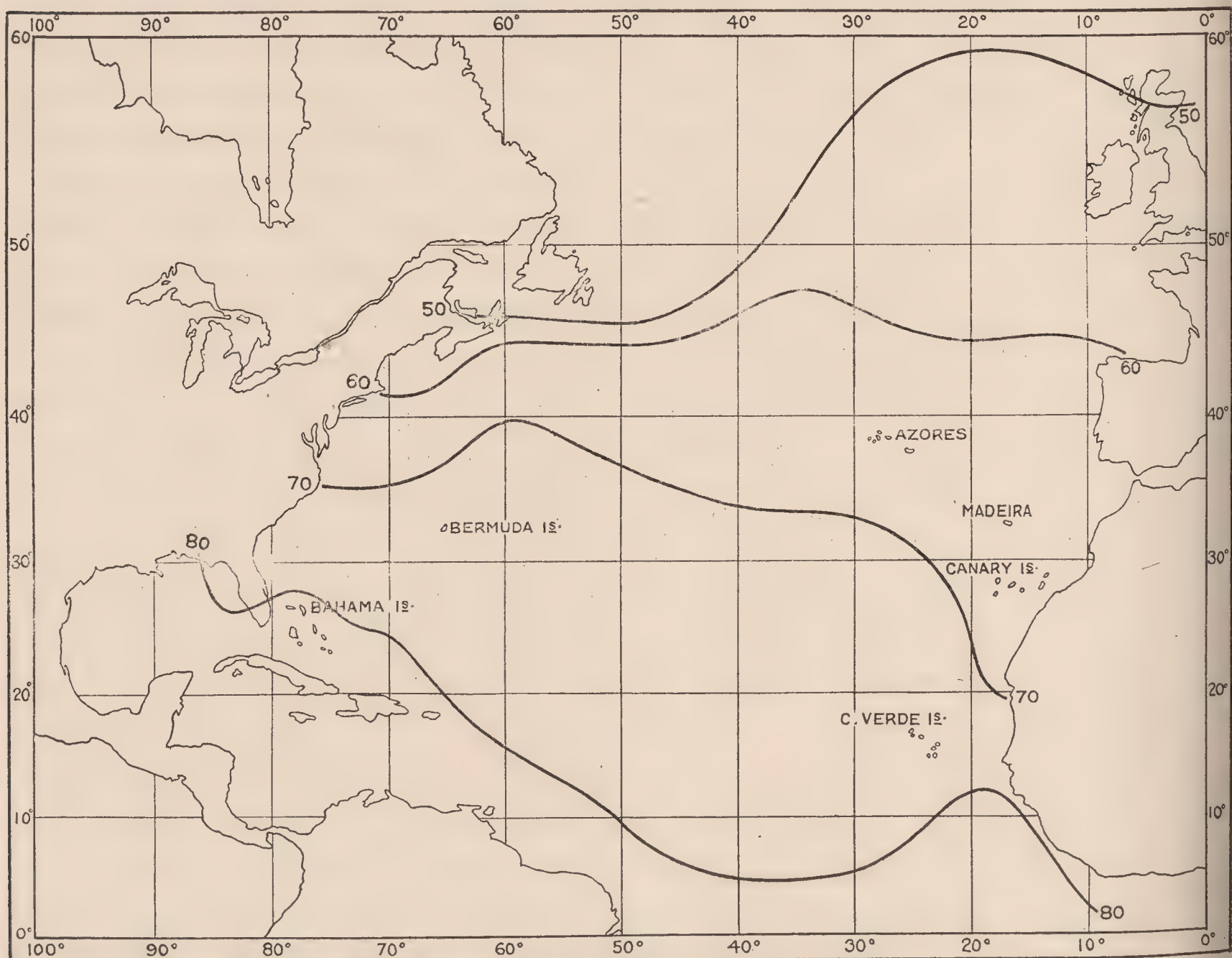


Fig. 2. Lines of equal mean temperature of the surface of the North Atlantic Ocean during June. The isotherms of 70° F. and 80° F. for this month coincide, respectively, with the southern limit of the breeding range of *Sterna hirundo* and the northern limit of the breeding range of *Anous stolidus*. The same isotherms show also the thermal effect of the Canary Current.

As to the presence of sufficient and appropriate food for a great population of boobies, tropic birds, petrels, etc., at the Cape Verdes, it is likely that the topography of the surrounding sea bottom, in conjunction with currents and vortices produced by the submarine slopes of the islands, is fully as important as the physical character of the sea water; for such circumstances compel a constant and plentiful store of varied food organisms to approach the surface in the vicinity of the birds'

nesting grounds. Conditions of this kind explain, for example, the abundance of the surface plankton in the Straits of Messina. Again, at the small island of Laysan, in the Pacific, Fisher¹ estimated that the consumption of cephalopods by the breeding albatrosses amounts to six hundred tons daily, and it is fair to assume that the mere shallowing of the ocean about the island accounts in large measure for the concentration of the avian food supply in the only layer in which it can become available, namely, the uppermost.

Of the six species of Tubinares which nest in the Cape Verde group, three (the *Oceanodroma*, *Bulweria*, and *Puffinus*) are essentially tropical types and members of species widely distributed in the Pacific as well as in the Atlantic. *Pelagodroma* and *Pterodroma mollis* are of somewhat more austral affinities, with representative forms not only elsewhere in the tropics but also southward to the border of subantarctic oceans.

The large shearwater (*Calonectris*) is more difficult to place, for it has close kin at more northerly oceanic islands, in the Mediterranean Sea, the Indian Ocean, and the eastern Pacific. It is best described as a small-sized, rather long-tailed representative of the well-known shearwater of the Azores and Canaries. Naturalists who cherish belief in the direct action of environment in the "speciation" process should note the fact that this bird is the darkest in coloration of its group, although it inhabits the most arid region of all. It is probably worthy of being ranked as a distinct species, but, for reasons stated below, the writer has preferred to treat it as a geographic race of *Calonectris kuhli*.

Several of the Cape Verde petrels, such as the *Bulweria*, the *Oceanodroma*, and the *Pelagodroma*, offer remarkable illustrations of discontinuous distribution, since colonies or aggregations of them are to be found only here and there throughout two or more of the great oceans. Bannerman (1914, pp. 442-444) has sought to explain the phenomenon upon the hypothesis of geological changes that have produced land barriers. After referring to the antiquity of the Tubinares, and the varying relations of land and water during the Tertiary, he adds:

"In former days the petrel family must have had a very extended range, which is yearly becoming more circumscribed. The birds which at one time ranged universally from the north Atlantic to the south Pacific are now becoming isolated in often widely distant localities. Intermediate colonies may be totally wiped out, for it has been often proved that all the Tubinares have a highly-developed homing-sense and become strongly attached to the particular breeding-station to

¹Fisher, W. K., Auk, 1904, p. 15.

which they resort. The birds will return year after year to the same small island no matter to what extent they are subjected to persecution from man, rats, mice, mongooses, or the other innumerable enemies with which ground-nesting birds have to contend."

In the same vein, Loomis¹ writes:

"In the remote past Tubinarine species became established in their habitats and have been able to hold them against all competition. Their success is perhaps due chiefly to the isolated character of their breeding stations, where predaceous land mammals are absent and food is plentiful. The discontinuous distribution of Harcourt's and Bulwer's petrels ceases to be an enigma when viewed from the standpoint of a water way between North and South America, which geologists tell us existed as late as the Miocene Period."

On the other hand, without resorting to such long periods of time, or such great secular changes, for an explanation of existing conditions, we might attribute the scattered tropical distribution of these birds to the loss of migratory instinct. During an age of more extensive glaciation in the southern hemisphere, the various species of petrels (which have obviously had their main center of dispersal in the south) may have made prolonged northward flights, just as *Oceanites oceanicus* and certain other Tubinares do to-day. The mere presence of available islands within the tropics would lead inevitably to colonizing by the more adaptable sea birds, and the continuance of a congenial environment would as surely bring about ultimate abandonment of a return migration to high southerly latitudes.

In the light of this hypothesis, the presence of *Oceanodroma castro* at the Atlantic islands, Hawaii, and the Galapagos, becomes scarcely more difficult to understand than the existence of a non-migratory species of penguin at the last-named archipelago.

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SYSTEMATIC LIST OF THE BIRDS

Since the publications of Alexander are in English and readily accessible, no attempt is made to repeat this ornithologist's excellent accounts of the land birds of the archipelago. Pertinent information in the writings of Bocage, Bolle, Dohrn, Keulemans, and Salvadori has, however, been freely transcribed.

In the case of the sea birds, the descriptions which are scattered through Alexander's papers have been brought together and quoted in whole or in part. Likewise, an effort has been made to incorporate all data of importance from the text of the other authors.

Pelagodroma marina hypoleuca

Thalassidroma hypoleuca WEBB, BERTHELOT, AND MOQUIN-TANDON, 1841, 'Hist. Nat. Iles Canar. Zool., Orn.,' p. 45 (Tenerife).

Pelagodroma marina ALEXANDER, p. 117, etc.

Pelagodroma marina hypoleuca BANNERMAN, 1914, p. 464.

LOCAL NAMES.—*Pedreiro azul*, *passaro azul*.

A resident species, recorded from Branco and the Rombos Islets.

The type locality of the species *Pelagodroma marina* is off the mouth of the Rio de la Plata (lat. 35° S.), and the breeding grounds of the

typical race are at the Tristan da Cunha group in the South Atlantic Ocean.¹ The North Atlantic form, which is said to differ from *P. marina marina* in its longer bill and lighter coloration, nests upon the Salvages as well as at the Cape Verdes.

Correia collected eighteen examples of this petrel at Cima, one of the Rombos Islets, between June 17 and 29, 1922. He also noted the presence of the species at sea in other parts of the archipelago.

Unfortunately, most of the collector's skins are of full-grown fledglings, as indicated by the character of the plumage and the flexibility of the cranial bones. It is not certain, in fact, that a single one of the specimens is an adult. Under these circumstances, a comparison with examples from colonies nearer the type locality loses critical value. Nevertheless, it is worth noting that all our Cape Verde birds differ from a pair of adults obtained at Great Salvage Island on April 29, 1895, in being grayer (less sooty) on the upper surface and in having a much broader white forehead. The breadth of the band from the base of the culmen is 6 mm. in the two Salvage specimens, and approximately 15 mm. in most of the Cape Verde birds. The difference may be due to a juvenal characteristic, as is doubtless the fact that the wings of the Cape Verde specimens are 10 mm. shorter than those of the Salvage birds.

Extreme and average measurements of the Rombos series follow.

8 males.—Wing, 141–149 (144); tail, 63–74 (66.5); exposed culmen, 17.4–19 (18.1); tarsus, 41–45 (44); middle toe with claw, 33.7–38 (36.4 mm.).

3 females.—Wing, 140–142 (141); tail, 62–70 (65.6); exposed culmen, 17–18.8 (17.8); tarsus, 43–46.5 (45.2); middle toe with claw, 35–40 (37 mm.).

Undoubted fledglings, with gray down still clinging to their bellies, have distinct white edgings on the upper tail coverts, the greater wing coverts, and the terminal parts of the secondaries and inner primaries.

Correia arrived at the Cape Verdes too late to find the eggs of this species, which had been previously taken by Alexander on March 15, 1897. Writing of the Cima Islet, that author reports (1898, p. 95):

“On the Brava side this island culminates in a rocky headland of considerable altitude, serving as a screen to hide from view the low, flat, gravelly land directly behind it, in length about two miles, and one in width at its broadest part. This portion was literally honeycombed by Petrels, causing the ground underfoot to give way at nearly every tread. The first species discovered was the elegant White-breasted Petrel

¹Judging from Dabbene's recent notes ('El Hornero,' II, pp. 246, 247, map on p. 254), birds referred to the typical South Atlantic race have been taken only twice at a distance from the breeding grounds, viz. off the coasts of Uruguay and northern Patagonia.

(*Pelagodroma marina*). We found it breeding in considerable numbers, the eggs being in an advanced stage of incubation. The nestholes had an average depth of 8 inches and a length of 2 feet. We are inclined to think that the female does the entire incubation, since every bird taken off its egg proved to be of that sex. The only three males obtained were in company with females and were not incubating.

"In unearthing these Petrels several managed to escape us. They ran along the ground in a dazed condition, and before we could rescue them they were pounced upon and carried off by Kites."

Alexander adds that this petrel's call notes are "grating noises like those of a pair of rusty springs set in motion."

Fea (*vide* Bannerman, 1914, pp. 464, 465) mentions that *Pelagodroma marina* was not breeding on Cima during his visit in the months of August and September.

Correia's field notes on the species, as translated from the Portuguese and somewhat shortened, follow.

I found the *pedreiro azul* ("blue stone-mason") chiefly in the vicinity of the Rombos Islets, but also saw two east of São Vicente. This bird flies very close to the water, frequently dragging its feet as though about to alight. It often travels by leaps from wave to wave, striking the water vigorously with its webs. When stopping to feed, it stands upon the surface as though the ocean were stone, the body being held lightly above by the extended wings. I did not discover the particular nature of its food, for the stomachs of the birds examined contained only a black oil.

On the Rombos Islet where this species nests, it seeks places in which the ground can be readily drilled, and then digs nearly straight down for three or four inches before beginning the lateral tunnel which may be a yard or more in length. The nest is unlined. The breeding birds are much persecuted by a kind of crab, which kills and eats them in their burrows. This enemy is a sand crab of a light yellow color, which carries itself well above the ground, and which is found not on the rocks but upon sand or earth. Indeed, it occurs only on islands which have sandy beaches and not at all upon those of sheer rock. When they are at rest the crabs excavate pits in the soil and disappear from view. These crabs seem to subsist mostly upon the flesh of petrels, which they hunt in their holes at night. I found many birds torn to pieces in the nest chambers, and afterwards I saw crabs picking bird bones, or dragging out fresh victims that they had captured. This caused me to observe more closely, and I noticed that the crabs regularly introduced themselves into the burrows at evening, leaving at once and moving to another nest if their search was not rewarded. Sometimes they would spend a whole night hunting in this way, often gathering a rich harvest.

Bird-eating crabs brought back by Mr. Correia have been identified as *Ocypodeippeus*, a widely distributed North African and southern Mediterranean crustacean.

Oceanites oceanicus oceanicus

Procellaria oceanica KUHL, 1820, 'Beiträge Zool. Vergl. Anat.,' p. 136 (*ex* Banks, Icon., Tab. 12) (South Atlantic Ocean, off the mouth of the Rio de la Plata).

A probable summer visitor, observed by the writer both to the southward and to the northwestward of the archipelago.

Oceanodroma leucorhoa leucorhoa

Procellaria leucorhoa VIEILLOT, 1817, 'Dict. d'Hist. Nat.,' nouv. éd., XXV, p. 422 (Picardie, France).

Oceanodroma leucorhoa BANNERMAN, 1914, p. 451; MURPHY, 1915, Auk, XXXII, p. 171.

A winter visitor to the archipelago.

Numerous specimens of Leach's petrel were obtained among the Cape Verde Islands by Dr. P. R. Lowe, of the British Museum, on January 13 and 14, 1906, as recorded by Bannerman. Others were collected by the writer south of Fogo, in lat. $10^{\circ} 46' N.$, long. $24^{\circ} 38' W.$, on September 27, 1912.

Oceanodroma castro castro

Thalassidroma castro HARCOURT, 1851, 'Sketch of Madeira,' p. 123 (Desertas Islets, Madeira).

Thalassidroma jabe-jabe BOCAGE, 1875, Jorn. Lisb. V, p. 120.

Oceanodroma cryptoleucura ALEXANDER, p. 117, etc.

Oceanodroma castro SALVADORI, p. 301; BANNERMAN, 1914, p. 459.

LOCAL NAMES.—*Jabe-jabe*, *pedreirinho*.

A resident species, recorded from Branco, Razo, São Nicolau, and the Rombos Islets.

This species, which is widely distributed in both the Atlantic and the Pacific, nests at Madeira, the Salvages, the Azores, and the Cape Verdes, as well as at St. Helena, or, as Bannerman has pointed out (Ibis, 1920, p. 561), at all of the so-called North Atlantic Islands except the Canaries, although the latter islands lie near the center of its breeding range.

Correia collected examples at Razo between May 17 and 26, 1922, and at the Rombos Islets between June 17 and 29. The series of eighteen skins includes both adults and young, in addition to eggs from Razo. The adults are in all respects identical with a male obtained at Porto Santo, Madeira, on June 12, 1903.

Measurements of the adult birds in the series from the Cape Verdes follow:

6 males.—Wing, 142–155 (148); tail, 64–74 (68.5); exposed culmen, 16–17 (16.2); tarsus, 22–24 (23); middle toe with claw, 22–23.5 (22.7 mm.).

6 females.—Wing, 143–157 (150.4); tail, 66–74 (69.8); exposed culmen, 15–16.6 (15.8); tarsus, 21.6–23.5 (22.6); middle toe with claw, 22–23.5 (22.5 mm.).

Three of the pure white eggs of this petrel, partly incubated, were taken at Razo, between May 17 and 26. They were cracked in transit, but two which can still be measured have the following dimensions: 24×31 and 23.6×31 mm.

Bannerman (1914, pp. 459, 460) sums up the published information regarding the status of *Oceanodroma castro* at the Cape Verdes, and shows that the known breeding season occurs between March and May.

Writing of this species on Cima, of the Rombos cluster, on March 16, 1897, Alexander (1898, p. 95) states: "In close proximity to *Pelagodroma marina* was a colony of *Oceanodroma cryptoleucura* [= *O. castro*], the burrows of which, however, ran further into the ground, besides being more tortuous. Many had young, while most of the eggs were well incubated."

Correia's field notes are as follows.

In the Cape Verdes the *pedreirinhos* ("little stone-masons") breed upon Cima, Brava, Razo, and São Nicolau. At Razo, where the ground is stony, they do not burrow to make a nest, but seek the shelter of projecting slabs of rock, beneath which they brood over their single egg. At Cima, however, they breed only in burrows and in soft soil. The nest-hole is about two inches in diameter and from six inches to a foot in depth, from where it may extend laterally two feet or more.

Bulweria bulweri bulweri

Procellaria Bulwerii JARDINE AND SELBY, 1828. III. Orn., II, plate XLV and text ("Madeira or the small islands adjacent.").

LOCAL NAME.—*João Preto*.

A summer resident, known from Razo and the Rombos Islets.

Bulweria bulweri, like *Pelagodroma marina* and certain other petrels, has a range of vast extent in both the Atlantic and the Pacific. The typical race is known to breed at Madeira and its outliers, at the Salvages and the Canaries, but it has apparently not hitherto been recorded as a resident of the Cape Verde Islands. Bannerman (1914, p. 443 and footnote on p. 489) lists it as only a "very rare straggler," this status being based upon Bocage's record of a single bird from Razo.

In view of the fact that Correia found *Bulweria* to be a not uncommon breeding petrel, well-known to the native fishermen by the folk-name of "Black John" (*João Preto*), it is rather surprising that neither Fea nor Alexander discovered it. A possible explanation is that the bird nests relatively late in spring, and "is not found inhabiting the north Atlantic Islands throughout the year" (Bannerman, 1914, p. 489).

Correia's twenty specimens comprise fifteen adult birds, together with twenty-five eggs, collected at Razo between May 17 and May 26, 1922, and two adults and three downy young obtained at Cima, Rombos Islets, between June 22 and July 2. His brief notes on the species state merely that the *João Preto* nests among loose stones, and that he seldom saw more than a pair, or at most four birds, in flight over the sea together.

The May birds, from Razo, have rather fresh tail and wing quills, and in at least one example the molt had obviously been recent. The Rombos specimens, which were taken a month later and which were caring for well-grown young instead of eggs, illustrate how greatly the abrasion of plumage is accelerated during the breeding season, when the adult birds are continually crawling in and out of rugged nest chambers. Not only the feathers but also the feet of the Rombos specimens show the effects of several weeks of partly terrestrial life, for the claws of these birds are worn down close to the ends of the toes.

Correia's series of *Bulweria bulweri bulweri* agree in appearance and dimensions with summer birds from Madeira and the Canary Islands. Measurements of the adult specimens from the Cape Verde Islands follow.

11 males.—Wing, 183–204 (193); tail, 100–112 (105.2); exposed culmen, 22–23 (22.5); tarsus, 27–29 (27.6); middle toe with claw, 29–32 (30.7 mm.).

6 females.—Wing, 189–202 (192.8); tail, 102–111 (106.6); exposed culmen, 21.2–23 (21.9); tarsus, 27–28 (27.5); middle toe with claw, 29–32 (30.7, mm.).

The pure white eggs show considerable variation in proportions, some of them approaching a conical shape. Six examples have the following dimensions: 31×45 , 31×41 , 30×43 , 31×42 , 31×44 , and 30×43 mm.

Pterodroma mollis feæ

Æstrelata feæ SALVADORI, 1899, Ann. Mus. Civ. Genova, (2) XX, p. 305 (São Nicolau, Cape Verde Islands).

Æstrelata mollis feæ BANNERMAN, 1914, p. 488.

Pterodroma mollis feæ HARTERT, 1920, p. 1431.

LOCAL NAME.—*Gon-gon*.

A North Atlantic subspecies, recorded from São Nicolau and Fogo.

This race of *Pterodroma mollis* breeds as far north as Madeira, Porto Santo, and the Desertas. The South Atlantic breeding grounds of the typical form, *P. m. mollis*, are apparently still to be discovered.

Bannerman sums up the information on the status of this species in the Cape Verdes as follows: "Fea's Soft-plumaged Petrel is even a rarer bird in the Cape Verde Group than it is in the Madeira Islands,

and although no eggs or young have been taken, it must undoubtedly breed there. In this archipelago it is restricted to the islands of St. Nicholas and Fogo, where Fea discovered it living on the former island 'always at an altitude of 500 metres.' This same traveller says it is to be found also on Fogo, *vide* Salvadori (Ann. Mus. Civ. Genov. ser. 2, vol. XX, 1899, p. 305). I gather from Fea's own account that he did not himself meet with the bird on Fogo, but constantly heard it spoken of by the natives of this island. Boyd Alexander did not come across this Petrel during his expeditions in 1897, but I have found an interesting note referring to this species in one of his private diaries, which I have been privileged to read. Under the date May 27th, while on a voyage down the west coast, he writes:—'Lat. 11° 10' N. "Black" Petrels still following in numbers, this afternoon great numbers of Shearwaters (*Æstrelata mollis*) suddenly appeared, they kept circling low over the water, soon all were left behind. . . . May 28th. Arrived Sierra Leone.' This entry is of particular interest, as it is the most southerly point that *O. m. feæ* has been noted, and is, moreover, the only occasion on which the bird has been seen in the month of May."

This petrel was not encountered by Correia. During September 1912, however, the writer saw considerable numbers of the birds at sea. They were first observed from the brig 'Daisy' on September 12, in latitude 23° 17' N., longitude 28° 19' W., upwards of three hundred miles from the islands. As the vessel neared the group, the petrels became increasingly common, and on September 15, the date on which we sighted Santo Antão, they were about in good-sized flocks. The following note of the same date is from the writer's field journal:

Mutton-birds (*Æstrelata mollis*) flew about singly or in pairs. They did not approach the brig of their own accord, but we came within half a length of one that was feeding upon what appeared to be the carcass of a large squid. The bird stood on the dead animal with raised wings and pecked rapidly. It did not fly off until we had come abreast of it.

In their manner of flight the petrels reminded me of marsh hawks. Any one who has seen a harrier foraging over windy salt meadows, alternately soaring and beating its wings, now rising, now just skimming the pulsing waves of green thatch, wandering capriciously and of a sudden darting downward, can imagine the way in which *Æstrelata mollis* hunts above the waves of the ocean. Of course the petrel is relatively longer-winged and shorter-tailed than the hawk, but the impression is similar.

On the following day we saw many flocks sitting on the water, facing the wind, with other birds sailing back and forth in air close to the cliffs of Santo Antão.

South of the archipelago, to about 9° north latitude, we saw more of these petrels on September 28 and 29.

Puffinus assimilis boydi

Puffinus l'herminieri boydi MATHEWS, 1912, 'Birds Austral.,' II, p. 70 (Cape Verde Islands).

Puffinus assimilis ALEXANDER, p. 117, etc.

Puffinus sp., SALVADORI, p. 303.

Puffinus l'herminieri boydi BANNERMAN, 1914, p. 483.

LOCAL NAMES.—*Pedreiro* (São Vicente), *batitu* (Brava and other southerly islands), *cagarra*.

An endemic subspecies, recorded from Branco, Razo, Rombos, São Thiago, and Fogo.

The Cape Verde race of *Puffinus assimilis* is the most southerly of all the Atlantic forms of the species. It has been recognized by Hartert ('Vög. paläarkt. Fauna,' II, 1920, p. 1422) as distinct from *P. a. godmani*, the race inhabiting the more northerly African islands, in the uniformly gray-brown under tail coverts, some of which have white borders, and in the darker inner vanes of the primaries. A comparison of Cape Verde skins with Madeiran specimens in the American Museum shows that the distinction is constant and well marked. I cannot follow Bannerman, however, in placing the Cape Verde shearwater closer to *P. l'herminieri* than to the *Puffinus* of Madeira.

Correia collected examples of this species at Razo between May 16 and 26, 1922, and at Cima, Rombos Islets, between June 22 and July 2. Among his twenty-three skins there are, unfortunately, but two adult breeding birds, all of the others being nestlings. Most of the latter are nearly full-grown, downy chicks, but several have molted all of the down and are distinguishable from the adults chiefly because of the rich blackness of their new feathers. Since a number of these fledglings are quite as large in all dimensions as the old birds, I have included the measurements of four of them in the tabulation summarized below:

3 males (1 adult, 2 young).—Wing, 169–180 (173); tail, 71–78 (75.3); exposed culmen, 25–29 (26.7); tarsus, 37–39 (38); middle toe with claw, 42–44 (43 mm.).

3 females (1 adult, 2 young).—Wing, 171–176 (173); tail, 75–80 (78.3); exposed culmen, 24–28 (25.8); tarsus, 37 (37); middle toe with claw, 40–43 (41.7 mm.).

This shearwater is apparently a permanent resident at the Cape Verdes. Fea obtained specimens at Razo as late as the end of October. Alexander collected eggs at Cima on March 15, while Correia's most advanced nestlings, which were doubtless ready to fly, bear the date of July 2.

Writing of his visit to Cima, Alexander (1898, p. 95) states that towards the rocky headland of the island he "discovered *Puffinus assimilis* breeding, not only in holes, but many beneath rocky boulders and

in small clefts and overhanging rocks, while in one instance a bird had made its nest beneath the boards of a tumbledown hut. In this last case the nest contained a quantity of dry grass."

At sea near the islands Alexander (p. 109) "saw numbers of *Puffinus assimilis*, and at intervals one of them would disappear and swim after some small fish just beneath the surface of the water, after the manner of a Penguin."

Again (p. 97), he writes:

"When the night shadows began to brood vaguely over this lone waste of an island, the Petrels came abroad and filled the still air with their weird cries. They mustered strongly, flitting to and fro over the low-lying ground in hundreds. Among the number the most noticeable was *Puffinus assimilis*, as it glided like some large soft-winged bat over the small sandhills, and even sometimes brushing past our camp-fire, forever uttering its weird cry "*karki-karrou, karki-karrou, karki-karrou. . .*"

"As the night wore on, the cries of these Petrels died away, only to recommence, however, with redoubled energy just as dawn arrived, and then, as soon as the dusky light waxed clear, these voices ceased as suddenly as they had commenced, indicating that their owners had crept noiselessly into their dark retreats, there to remain till the heat had once more abated."

Correia's field notes follow:

I saw these shearwaters about many islands of the Cape Verdes, but never in large flocks like those of some of the other petrels. Their flight is exceedingly rapid and always close to the surface of the sea. When feeding, they spend much time below, sometimes emerging at a great distance from the spot at which they had disappeared.

On land the only examples that I saw were at Razo and Cima. Razo has a great population of them, and the fishermen said that there were also many at Branco. I was at Razo in May, and every night these birds fluttered and criss-crossed over their breeding grounds, chattering continually. Most of the chicks in the nests had changed from down to feathers, and were about ready to fly.

At Razo these shearwaters nest under fragments of stone, but at the Rombos Islets they live in burrows. They feed themselves on small fish. The inhabitants of the northern islands call this bird the *pedreiro*, but to the people of Brava it is the *batitu*.

Calonectris kuhli edwardsi

Puffinus Edwardsii OUSTALET, 1883, Ann. Sci. Nat., (6) XVI, Art. 5, p. 1 (Branco, Cape Verde Islands).

Puffinus mariæ ALEXANDER, p. 92.

Puffinus edwardsii, SALVADORI, p. 302.

LOCAL NAME.—*Cagarra*.

An endemic subspecies, recorded from Branco, Razo, and Brava.

This very distinct shearwater, known only from the Cape Verde group, was described in 1883, but it has been generally overlooked, and its name has appeared in no systematic account of the Tubinares except Godman's 'Monograph of the Petrels' (1908). As will be shown below, this *Calonectris* differs so greatly from the related shearwater of the Azores and the Canaries that it may well merit the specific rank given by Oustalet. Lacking material, however, for a study of the four or more representatives of *Calonectris kuhli*, the writer prefers for the present to regard the Cape Verde form as one of the geographic races.

Alexander found that this shearwater did not inhabit the Rombos Islets, but that it occurred on Brava and on outlying rocks. He writes (1898, p. 108):

"Raza and Branca may be looked upon as the chief habitat of this species. Before landing on Raza we saw a large flock in a wedge-shaped formation sleeping on the water. They frequent chiefly the hollows in the cliffs, but we found some on the higher ground in holes made by the birds themselves underneath large boulders, where the entrances were strewn with small stones and flakes of rock, evidently brought there by the birds, since the soil is of a fine nature.

"These Shearwaters appear to prey upon smaller birds, for in many instances the vicinity of their holes was strewn with bones and feathers. While on Brava, we constantly heard this bird at night among the hills; its weird cry, only enhanced by the silence, is like the whistling cry of the Wigeon. When fishermen land on Raza, they capture many of these birds for eating purposes, sometimes taking away almost a boat-load to their homes."

During his second visit to the Cape Verdes, Alexander found the shearwaters breeding (1898, p. 284):

"While on Raza we found that this Shearwater had young. The eggs are laid in September, and should the first be taken another is laid. Albinism occurs in this species, but unfortunately I arrived on the scene too late to prevent the destruction by some fishermen of a perfect albino specimen. However, we managed to obtain several specimens which exhibit a distinct tendency towards albinism. During the two weeks we stayed on Raza over 3000 of these Shearwaters were captured by the fishermen, who prepared them for food."

Correia obtained a beautiful series of the shearwaters at Razo, between May 16 and 24, and on Brava and its islets, between July 4 and 6. On the latter dates he collected also a large number of eggs,

proving that the nesting season begins much earlier than was surmised by Alexander. Although his visit was too early for him to see living young birds, he found the mummy of a nestling of an earlier year in which the gray down, whitish on the belly, is perfectly preserved. This chick resembles closely young specimens of *Calonectris kuhli borealis* from the Azores, except that the down of the Cape Verde bird is of a lighter and clearer gray. Correia noted that the species has its greatest center of abundance on Razo, but that it is common also on the southern and western coasts of Brava, and on the rocks off shore. Like earlier visitors, he found none on the Rombos Islets. His account of the habits of the shearwater follows.

The *cagarra* is one of the most curious of the birds I encountered. It leads an entirely different life from the other sea fowl. The open ocean is its home during the day, but if by chance any remains on land, no eye sees it for it hides in deep cavities of the rocks.

Before daybreak the cagarra leave the holes which have served them as resting places for the night, and when they have banded into a large company (which takes half an hour or more of flying from side to side along the rocks), they depart to sea, sometimes five or six hundred together. All this is before sunrise. Those which still happen to remain in their hiding places after dawn, do not leave at all on that day, but wait over until the following; nor do those which have flown to sea return until after the setting of the sun.

When the cagarra come back at nightfall, they do not all go directly to their retreats. Some remain in the vicinity of the shores, sailing about for hours; others fly far into the interior parts of the islands, and while on the wing they are never silent, for their 'Ha-oo!' rings out constantly. While the night is still young, however, they all settle down to sleep, and then they remain in silence until the hour before dawn. Not all of them seek a hole in which to pass the night, for some are content with ledges of the cliffs or undercuttings of the rocks. Most of these sleeping quarters, by the way, seem to be different from the cavities and burrows in which they lay and hatch their eggs.

Another curious circumstance is that these birds come to land only on dark nights, except during the breeding period. In the season of moonlit nights they ordinarily remain at sea during both daylight and dark, and only after the moon is well on the wane do they begin to return in numbers to sleep ashore.

I observed that the cagarra do their courting at sea. They rest on the water in large congregations, sometimes forming rafts of birds a hundred feet square, and at such times the love-making goes on with much caressing of bills and necks. During the amorous pursuits of one bird after another, conflicts take place which often involve more than the single pair. Sometimes I saw regular battles between groups of the birds.

The cagarra hunt their food while flying about in seemingly unorganized flocks. It appears to consist entirely of fish, of which I was able to recognize in their stomach contents four kinds, namely, *cavalla* (mackerel), *sardinha* (herring), *chicharro*, and *voadór* (flying-fish).

During the period when the single large white egg is in the burrow or rocky chamber, the female bird is always brooding, the male cagarra bringing her nourishment when he returns from sea in the evening. He carries the fish not in his beak, like the tropic birds, but in his stomach, and he ejects the food into the mouth of his mate while she sits upon the egg. I observed all this one night when I sat up with the object of seeing their intimate home life. I had a lantern which I uncovered only when one of the birds alighted at its nest, and from a distance of a yard or so I saw the birds which had just come in, and which were recognizable from their wet feet, vomit the fish into the beaks of their mates.

The measurements of the Cape Verde shearwaters will be found tabulated below. The eggs (Fig. 8) collected at Brava are uniformly clear white and of fine texture. They are characteristically variable as to size and contour. Ten, selected for variation, measure as follows: 43×59 , 45×68 , 44×64 , 44×57 , 46×65 , 41×61 , 46×60 , 44×62 , 46×69 , 45×68 mm.

Of the four forms of *Calonectris kuhli*, the writer has now studied large series of *edwardsi* from the Cape Verdes and of *borealis* from the the Azores, as well as six specimens of the typical Mediterranean race.¹ He has, however, seen no examples of *C. k. flavirostris*, which is supposed to breed at Kerguelen Island or elsewhere in the Indian Ocean.

In dimensions, *C. k. kuhli* is intermediate between *edwardsi* and *borealis*, the average measurements of four males of *kuhli* in the American Museum and the Museum of Comparative Zoology being as follows: Wing, 337; tail, 125; exposed culmen, 47; tarsus, 51.5; middle toe with claw, 63.5. It is, nevertheless, the most distinctive of the three forms, having conspicuous whitish edgings on the feathers of the forehead, and a large white field on the inner vanes of the primaries, diagnostic markings which are lacking both in *edwardsi* and *borealis*. With regard to the latter races, *edwardsi* is darker on the head and back than *borealis*, but the outstanding difference is one of size.

The possession by the American Museum of large series of Azorean and Cape Verde Island shearwaters from the respective breeding grounds offers an exceptional opportunity for inquiry by statistical methods into the subjects of individual variation and subspecific relationship.

Variation within a species may be of at least five types, namely, (1) geographic, (2) age, (3) seasonal (including not only changes in color of plumage, but also variation in certain dimensions due to molt or other causes), (4) sexual, and (5) individual. Only variations of the first class properly affect classification, but variations due to one or more

¹See the following papers, in which the recent literature is cited: Murphy, R. C., 'Notes on Tubbinares, including Records which Affect the A. O. U. Check-List,' Auk, 1922, pp. 58-65 (58-60); 'Notes on a Small Collection of Birds from the Azores,' Ibis, 1923, pp. 44-49 (45, 46).

of the other four causes have all too often been made the basis of untenable changes in the system. Among Tubinares the problems of true individual variation are doubtless the most fundamental of all, for not only have such been wrongly employed in the so-called splitting of species, but they have, with equal error, been put to quite the opposite purpose when results due in reality to geographic, sexual, or age variation have been attributed to individual variation. The fact that the bulk of Tubinares existing in the older collections were taken on the wide ocean, far from nesting grounds and often in localities where genetically and geographically distinct strains of one species mingle during the non-breeding season, has led numerous ornithologists to consider most species or races of these birds as extraordinarily erratic in their individual facies. As a matter of fact, study based upon adequate data has suggested repeatedly that, except for the phenomenon of dichromatism, individual variation is seldom notably great among at least the smaller and more rapidly maturing species of the group.¹ Loomis has, indeed, called attention to an indubitable example of marked individual variation in the form of the bill within a single breeding colony of Galapagos albatrosses (*Diomedea irrorata*).² When, however, he extends his deductions to cover "like discrepancies" among eighty-one specimens of another species "obtained on the high sea," his ground is far less sure. Slight structural differences in birds collected on the high sea usually offer no clue as to whether they should be regarded as individual or geographic, and in attacking this problem it is essential to compare like only with like.

With the object of ascertaining the range of true individual variation, as distinguished from variations of every other type, among the Cape Verde and Azorean shearwaters, the writer has selected at random 100 breeding specimens of *Calonectris kuhli edwardsi* (50 of each sex), and 100 breeding specimens of *C. k. borealis* (50 of each sex). These 200 birds were all collected by Mr. Correia. The specimens of *borealis* were obtained at the single island of Pico, Azores, within less than one month's time (July 11–August 7, 1921). The specimens of *edwardsi* were obtained at Razo and Brava, Cape Verde group, between May 16 and July 6, 1922. In both instances, therefore, the chosen specimens are all fully adult; they are in approximately the same physiological state with reference to the time of reproduction, i.e. in uniform condition of plum-

¹Cf. Murphy and Harper, 1921, Bull. Amer. Mus. Nat. Hist., XLIV, pp. 526–533. (Consideration of individual variation in *Pelecanoides georgicus* and other petrels.)

²Emu, 1920, p. 310.

TABLE III

100 Breeding Specimens of <i>Calonectris kuhli edwardsi</i>		Minimum	Maximum	Average, Including Probable Error
Wing	50 males	289	320	304.6 $\pm$ 0.56 mm.
	50 females	284	316	297 $\pm$ 0.71 mm.
Tail	50 males	113	131	120.7 $\pm$ 0.34 mm.
	50 females	114	128	120 $\pm$ 0.31 mm.
Exposed Culmen	50 males	41	49	44.7 $\pm$ 0.10 mm.
	50 females	39	46	42.5 $\pm$ 0.14 mm.
Tarsus	50 males	45	50	47.1 $\pm$ 0.10 mm.
	50 females	43	48	46.1 $\pm$ 0.12 mm.
Middle Toe with Claw	50 males	56	64	59.3 $\pm$ 0.16 mm.
	50 females	55	63	57.9 $\pm$ 0.18 mm.

age, etc. In short, they are seasonally and geographically comparable, and the sexes are equally represented. Since the skins were put up by one collector, the "make" is similar throughout. Finally, all measurements were made by the writer, and with the same instruments.

While 100 specimens of a form are but a small total from the point of view of a biometrician, the number is a relatively large one to a vertebrate taxonomist. Statistical data derived from such a series should at least indicate the range of true individual variation far more reliably than similar data obtained from specimens of indeterminate origin.

In preparing the necessary tables, five common measurements of ornithological usage were employed, namely, those of wing, tail, exposed culmen, tarsus, and middle toe with claw. Smaller dimensions, such as depth of bill, were omitted chiefly because of the increased probability of error in manipulation. Recent references to tables of measurements prepared by the writer¹ render it desirable to describe the methods.

WING.—The chord of the distal segment, from the carpal bend to the tip of the longest primary, taken with anthropometric calipers graduated in millimeter units. European ornithologists usually straighten the quills against a plane when taking this dimension, a method which yields figures appreciably greater than those for the chord.

¹For example, Mathews and Iredale, 'Manual Birds Australia,' Vol. 1, 1921, p. 49, write: "Nichols and Murphy contrasted Mathews's measurements [of albatrosses] with their own; but we would point out that their method of measuring is unknown to us and we cannot reconcile any of their figures with our own data."

TABLE IV

100 Breeding Specimens of <i>Calonectris kuhli borealis</i>		Minimum	Maximum	Average, Including Probable Error
Wing	50 males	329	367	351.5±0.77 mm.
	50 females	329	362	344.3±0.68 mm.
Tail	50 males	122	140	130.2±0.41 mm.
	50 females	121	138	129.3±0.37 mm.
Exposed Culmen	50 males	51	59	55.5±0.16 mm.
	50 females	49	57	52.9±0.18 mm.
Tarsus	50 males	54	59	57 ±0.11 mm.
	50 females	51	57	54.6±0.12 mm.
Middle Toe with Claw	50 males	67	74	71.6±0.17 mm.
	50 females	65	73	69 ±0.18 mm.

The remaining measurements were all made with sharp-pointed steel calipers. The dimensions were first recorded and averaged in millimeters and tenths, but for purposes of subsequent tabulation the decimals were eliminated, those of 0.4 mm. or less being dropped, those of 0.6 mm. or more being considered as 1 mm. Fractions of exactly 0.5 mm. were assigned alternately to the next lower and the next higher unit.

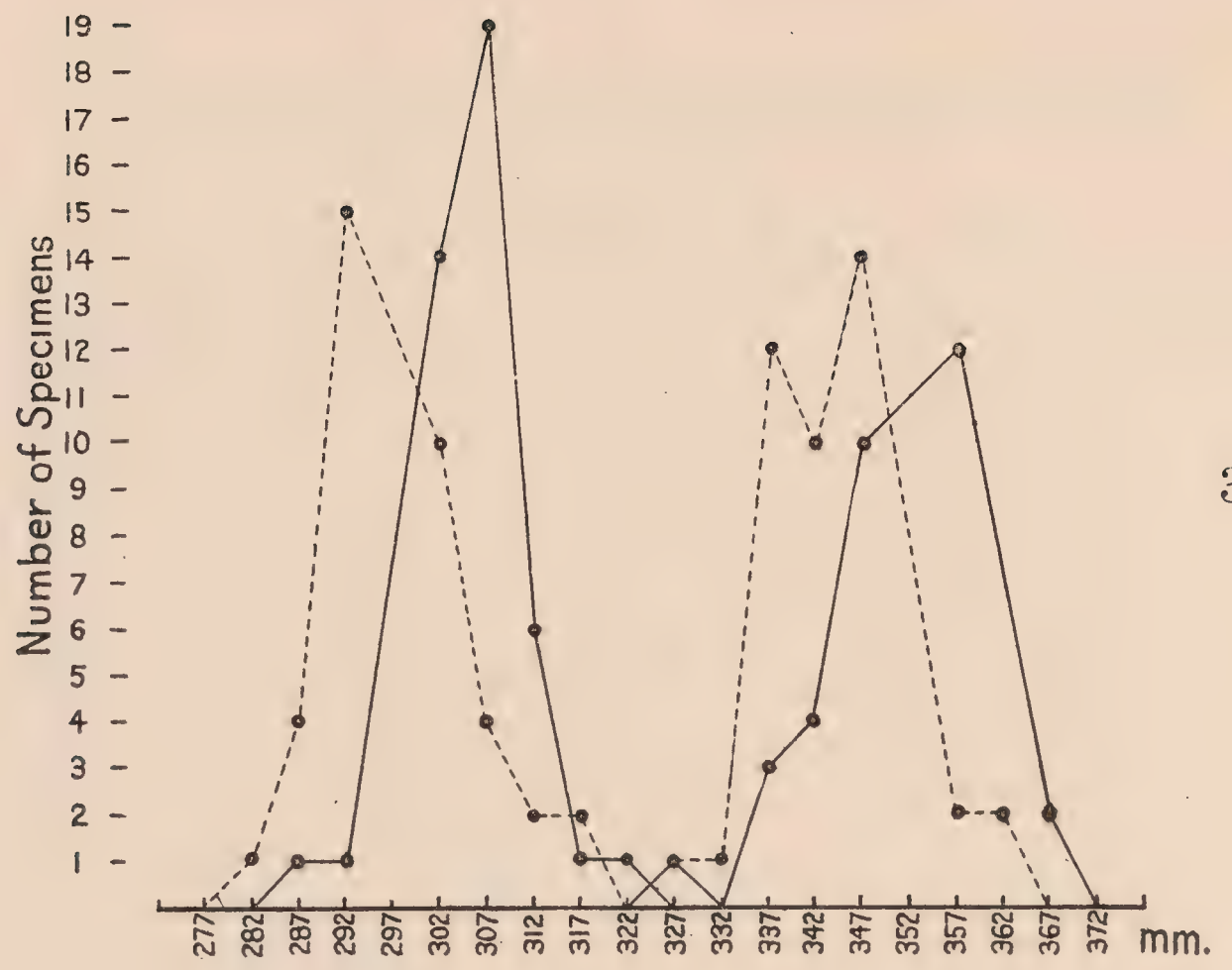
TAIL.—The distance from the base of the two central rectrices to the tip of the tail. In taking this measurement one of the points of the calipers was thrust between the two quills at the spot at which the skin enveloped their shafts.

CULMEN.—The distance between the well-marked depression at the base of the culminicorn and the most distal point of the strongly hooked bill.

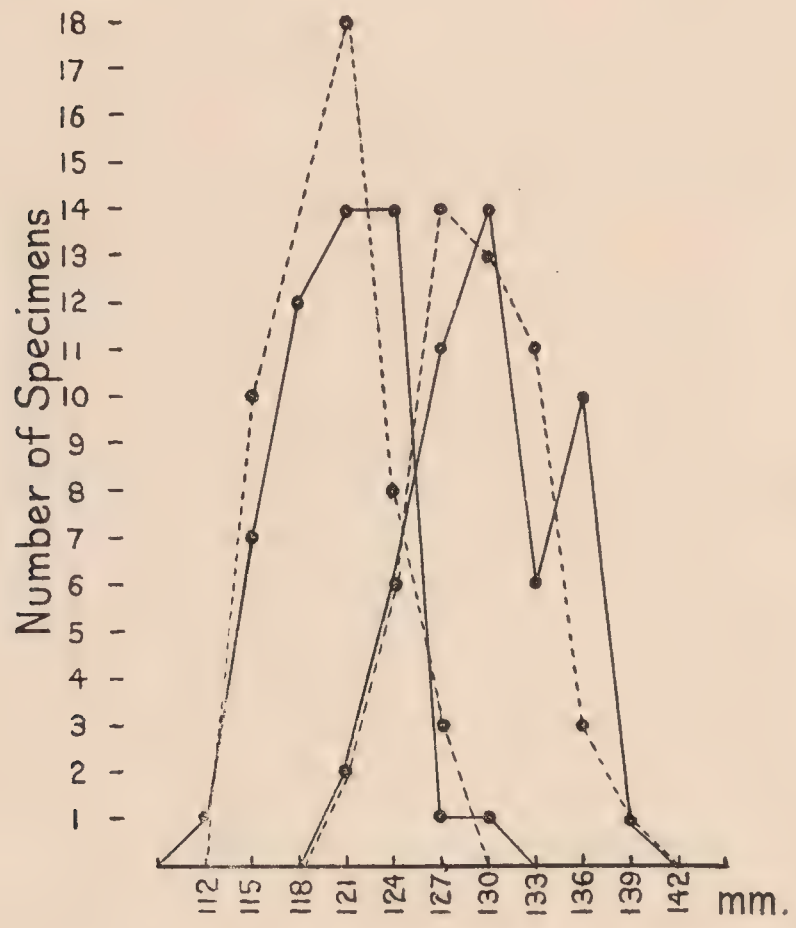
TARSUS.—The extreme length of the tarsometatarsal bone, obtained by thrusting the proximal point of the calipers through the skin, on the antero-external side of the heel joint, and the distal point into the joint between the middle condyle and the toe.

MIDDLE TOE WITH CLAW.—The distance between the base of the first phalanx and the tip of the nail, measured on the upper or anterior side. The toe was, of course, straightened before the calipers were applied.

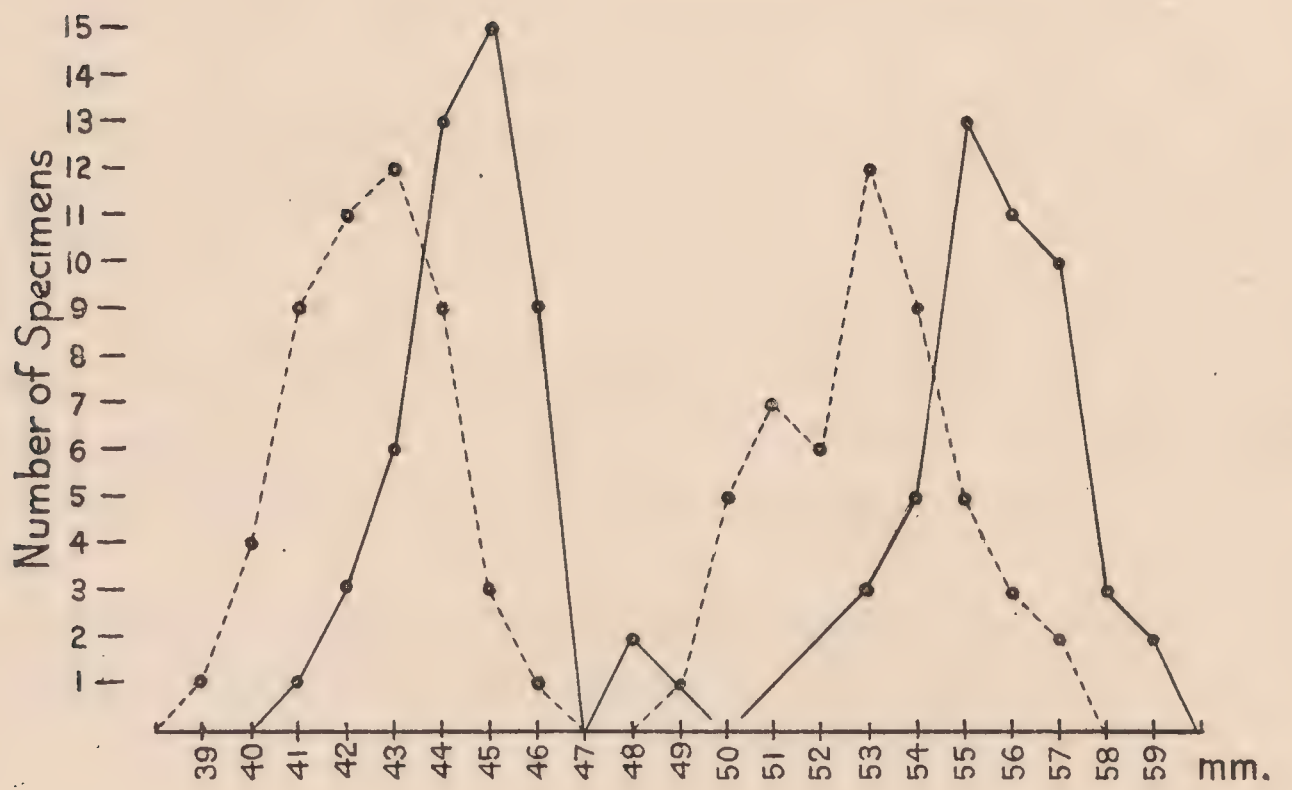
The extreme and average dimensions of the fifty male and fifty female specimens of the Cape Verde and Azorean shearwaters, respec-



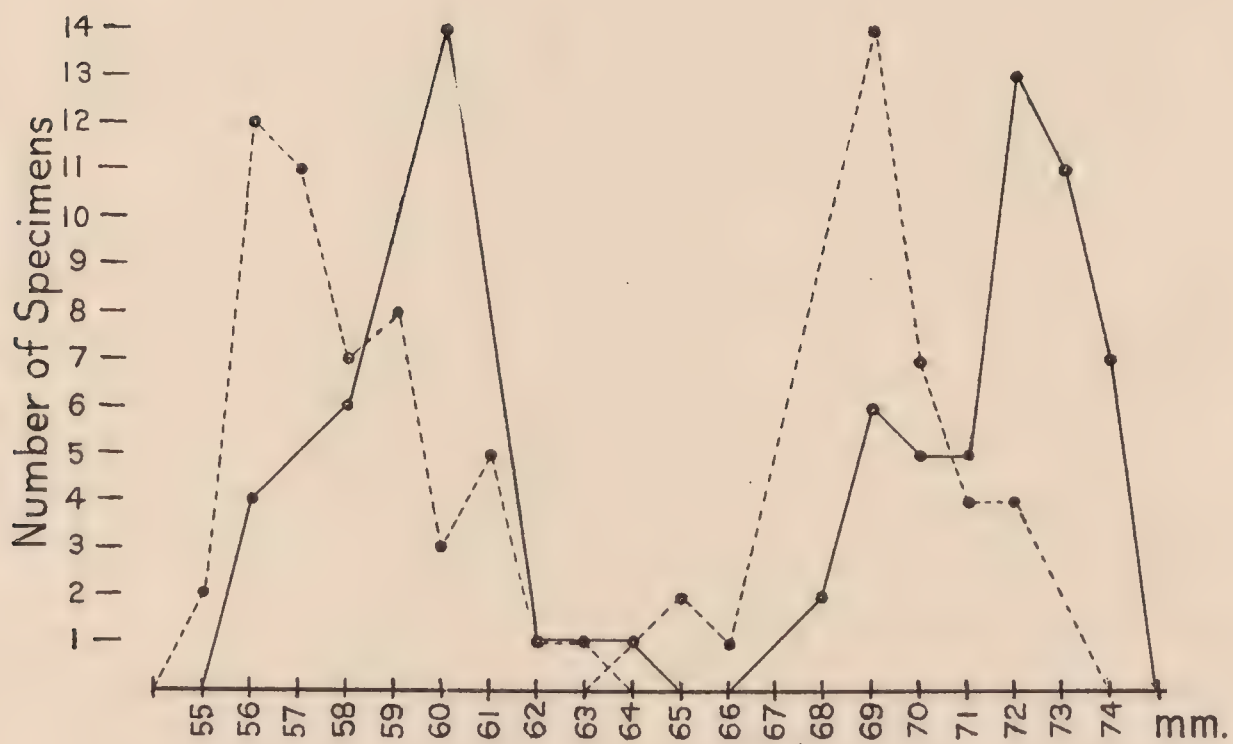
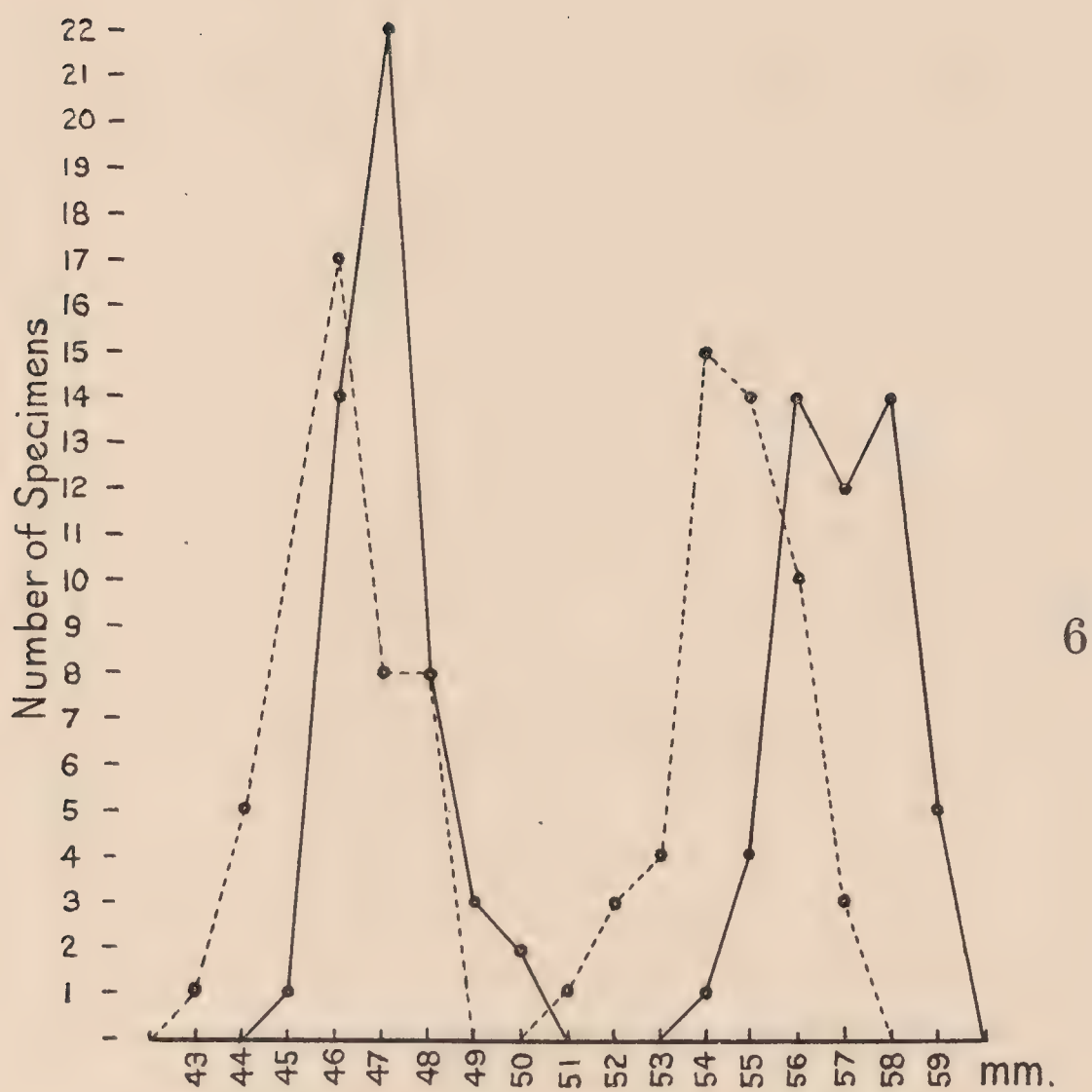
3



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5



Figs. 3-7. Frequency distribution graphs showing size of 50 males and 50 females of *Calonectris kuhli edwardsi* (left pair of curves in each figure), and *Calonectris kuhli borealis* (right pair of curves in each figure). Solid lines represent males; broken lines females.

- Fig. 3. Wing.
- Fig. 4. Tail.
- Fig. 5. Exposed Culmen.
- Fig. 6. Tarsus.
- Fig. 7. Middle toe with claw.

tively, are recorded in Tables III and IV. The decimal figure which is expressed as a plus-or-minus quantity after the mean for each dimension, represents the probable error of this mean as derived through the ordinary statistical methods. This quantity has a definite bearing upon problems of variation in that, according to the theory of statistics, differences in excess of three times the probable error of a given mean are considered to be significant.

Graphic expression of the entire series of measurements, as in figures 3-7, has a distinct advantage over the tables in that it reveals at a glance the relative frequency of each dimension, from minimum to maximum, as well as the relative proportions of the two sexes, and of the two geographic forms. In these graphs, the figures along the base line represent the total range in length of the respective structures, while the vertical figures indicate the number of specimens falling within each class. In the smaller structures, namely bill, tarsus, and toe, the class-range is of the smallest unit, i.e. one millimeter. The class-range of the tail is three millimeters and that of the wing five millimeters, the abscissas having been taken from the mid-point of each class. Solid lines represent the curve for males, dotted lines for females. The pair of curves at the lower or left end of each base-line represents, therefore, the range in size of 100 examples of the smaller form, *Calonectris kuhli edwardsi*, of the Cape Verde Islands; the right hand curves present similar data for *Calonectris kuhli borealis*, of the Azores.

As regards the variability and average differences of the sexes and of the geographic forms, respectively, the general conformity of the several curves is noteworthy. It will be observed also that *edwardsi* and *borealis* exhibit no intergradation in size, even between the largest males of the former and the smallest females of the latter, except in the case of the tail, in which structure the marked overlapping is coincident with practical lack of sexual difference.

Upon the evidence presented, many ornithologists would unhesitatingly consider the Cape Verde *Calonectris* specifically distinct from the bird of the Azores. So far as known, there is no intergradation between the two and the ranges appear to be widely separated. In default of specimens of *C. k. flavirostris*, however, as well as of an adequate series of Mediterranean topotypes, this question may here be left in abeyance. Hartert has suggested ('Vögel paläarkt. Fauna,' II, p. 1425) that *Calonectris creatopus*, of the west coast of America, is a member of the same assemblage. Whatever the precise interrelationships may be, it is apparent that the several representatives of *Calonec-*

tris kuhli, together with *C. creatopus*, comprise what the modern German ornithologists call, by a useful term which has no exact equivalent in English, a "Formenkreis."

Phalacrocorax carbo lucidus

Halieus lucidus LICHTENSTEIN, 1823, Verzeichniss Doubl. Zool. Mus. Berlin, p. 86 (Cape of Good Hope).

Phalacrocorax lucidus ALEXANDER, p. 117, etc.

LOCAL NAME.—*Corvo marinho*.

A permanent resident, recorded from Razo, São Nicolau, and Boa-Vista.

Sula leucogaster leucogaster

Pelecanus leucogaster BODDAERT, 1783, 'Tabl. Planch. Enlum.,' p. 57 (Cayenne).

Sula fiber KEULEMANS, p. 372; ALEXANDER, p. 117, etc.

Dysporus sula DOHRN, p. 8.

Sula leucogastra SALVADORI, p. 308.

LOCAL NAME.—*Alcatraz*.

A permanent resident, recorded from Santo Antão, São Vicente, Razo, São Nicolau, Sal, Boa-Vista, São Thiago, Brava, and the Rombos Islets.

At the Cape Verde Islands, *Sula leucogaster* reaches its most northerly breeding station in the eastern Atlantic. The bird has never been reported from the Canary Islands, even as a wanderer.

With reference to the boobies of Brava, Alexander (1898, pp. 93, 94) writes:

"Owing to the proximity of their breeding-station on Rombos Islands, Gannets, singly or in pairs, were constantly to be seen hanging about the coast in search of food, while it was not uncommon to catch sight of flocks of from 15 to 20 beating over the smooth sea in a compact wedge-shaped body; sometimes skimming over the surface in graceful and steady flight, sometimes rising high in the air—mere specks in the sky—as they prepared to pass over the Brava hills in order to reach another part of the coast. The dexterity with which the species catches its prey must be seen to be appreciated. As soon as the fish is sighted, the bird, with closed wing, shoots into the water, the next moment to reappear floating on the surface busy tackling its prey and looking for an instant like a bird mortally wounded. Sometimes, however, a series of rapid twists and turns are indulged in prior to the dive, some 20 feet above the water. These movements may either result from the presence of a shoal of fish, the sight of which causes the bird to waver in its choice, or to a single fish having altered its course.

"Besides being much smaller than the female, the coloration of the soft parts in the male is altogether brighter, while the remarkable patch of bluish slate-colour visible in front of the eye in the female is continued round it in the male. The webs also in the feet of the latter are of a greenish yellow."

Later, visiting the largest islet of the Rombos group, the same author (p. 96) found, on March 15, a rocky headland "where the steep sides had been here and there made hoary by the hundreds of Gannets that peopled them. On the long narrow ledges of rock facing the sea countless numbers of these birds were standing in serried ranks, bolt upright. Wherever a portion of this rock possessed a superficial covering of earth they nested in dozens, hardly 2 feet intervening between the nests. These consisted of a shallow depression made by the bird itself, and further bordered by a fringe of small pebbles and flakes of rock. Both sexes share in the incubation, and we nearly always found the male on the nest throughout the day. Incubation was well forward, nestlings being in every hollow, but only one in each; invariably the second egg of the clutches had turned out wrong. There were, nevertheless, many fresh eggs, but sad havoc is constantly made among them by the fishermen whenever they visit the island. The birds, too, do not escape molestation, often being stoned on their nests and killed for eating purposes."

Correia collected an excellent series of thirty-five skins of this booby at Razo and Cima, between May 18 and July 1, 1922, together with numerous eggs from the Razo colony. All of the skins are of either fully adult, breeding birds or of nestlings; there are no intermediate examples in which the gray juvenal belly feathers are being replaced by white. One well-grown downy chick, which still shows no trace of quills, is dated Cima, June 29. All other young birds obtained in late June had molted the last of the white down.

The entire series of Cape Verde skins agrees in all respects with topotypical specimens from the Caribbean, as well as with birds from Fernando Noronha (the nearest breeding station on the western side of the Atlantic), the coast of Brazil, and the Bahama Islands. It is evident that but one race of *Sula leucogaster* inhabits the tropical Atlantic.

Measurements of twenty adult birds from the Cape Verde Islands are summarized below. It will be seen that females are larger than males, as reputed, but that the average difference is not great, amounting to perhaps five per cent in the length of the bill and middle toe, and to less than this in the other dimensions.

10 males.—Wing, 378–411 (392.2); tail, 173–208 (190); culmen, 90–100 (94.7); tarsus, 45–51 (47.9); middle toe with claw, 76–84 (79.8 mm.).

10 females.—Wing, 395–412 (404.3); tail, 177–200 (191.5); culmen, 97–102 (100.1); tarsus, 47–51 (48.8); middle toe with claw, 82–90 (86.1 mm.).

The eggs (Fig. 10) from Razo, all taken between May 18 and 25, are remarkably variable as to shape and size. Thirty of them fall within the following axial dimensions: breadth, 37–43.5; length, 53–64 mm.

Correia's field notes on the booby are as follows.

This bird lives in great flocks at the Cape Verde Islands, especially on uninhabited islets where there are no fresh water springs. Razo, which is visited only by fishermen, is both a summer and winter home for the *alcatraz*, and apparently the birds never go more than a few miles from their insular breeding ground in search of the fish upon which they subsist. Only the western portion of Razo, however, is occupied by the boobies.

What caused me most surprise was to see boobies of all ages at the same time—some laying eggs while others had downy youngsters or fledglings ready to leave for sea. But the fishermen assured me that this species lays eggs during every month of the year, and that there is no season when nestlings are not common.¹

The fishermen are the boobies' greatest enemy, for large numbers of the birds are salted, sun-dried, and subsequently roasted on coals, precisely like fish. The Cape Verders pay little attention to booby eggs, for they prefer the birds themselves as food, and it is safe to say that thousands are killed annually.

The booby seems to be absolutely indiscriminate in the choice of a nest; any haphazard site will serve, and no building materials are used. Three eggs are usually laid, with long intervals between each laying. In examining a set in one nest I observed that a chick was about ready to break the shell of one, while the second egg contained only a small embryo, and the third was so fresh that it might have been eaten. Again I saw three chicks in a nest, one so large as to be able to take care of itself, the second capable of lifting its head only with difficulty, and the last just emerging from the egg shell. Such incidents led me to believe that there is normally a period of many days between the deposition of the eggs.

The booby is hatched naked, and two weeks pass before it is completely covered by the snow-white down. The dark wing plumes are the first feathers to appear, but eventually the nestling, after reaching full growth, exchanges the down for a coffee-tinted plumage. In young birds the bill and feet are dark, but they later turn successively to light gray, creamy flesh-color, bleached green, and yellow or orange-yellow which is the final hue.

The booby dives five or six feet into the water in order to obtain fish. I found various species in the stomachs of the birds, including the *chicharro*, *sardinha* (a herring), *voadór* (flying-fish), *dobrada*, *agulha* (needle-fish), *bicuda* (barracuda), and others whose names I do not know. The birds hunt until dark, and then always come to land, sitting on the rocks until daybreak. They carry fish in their crops to the young, and the latter cause great confusion by their outcries and their efforts to introduce all their heads together into the mouth of the parent. The old birds, how-

¹Bolle states that in his time (1856) a boat went from São Nicolau to Razo for fresh eggs during October.



8



9



10

Figs. 8-10. Variation in the Eggs of Cape Verde Island Sea Birds.

Fig. 8. Eight eggs of *Calonectris kuhli edwardsi*. Fig. 9. Eight eggs of *Phaethon aethereus*. Fig. 10. Eight eggs of *Sula leucogaster*.

ever, calmly let the chicks tire themselves out before responding. The lazy fledglings continue to beg for food long after they seem capable of catching fish for themselves. When either old or young birds are startled, they usually vomit a few fish before flying or running away. The flocks of boobies are very sheeplike, for when one bird takes flight the others follow, and when the first returns it is a signal obeyed by all.

Some miles west of Brava, on September 19, 1912, the writer saw a flock of boobies following a school of albacores during a squall. The massed fishes in pursuit of their prey were breaking water continually, and the boobies, sailing in the high wind above, seemed to be struggling for the scraps. A few small, unidentified terns were among the larger birds.

Phaëthon æthereus

Phaëthon æthereus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 134 (Ascension Island); ALEXANDER, p. 117, etc.

Phaëton candidus KEULEMANS, p. 373.

Phaëton æthereus SALVADORI, p. 308.

LOCAL NAMES.—*Rabo de junco, rabi-junco, junco.*

A permanent resident, recorded from São Vicente, Razo, Sal, Boa-Vista, São Thiago, and the Rombos Islets.

The Cape Verde Islands, which are some 1400 geographic miles from Ascension, the type locality of *Phaëthon æthereus*, mark the northerly outpost of the breeding range of tropic birds in the eastern Atlantic. Toward the western sides of all the great oceans, where tropical oceanographic conditions obtain farther from the equator, the several species of Phaëthontidæ have more extensive latitudinal ranges. A form of *Phaëthon lepturus*, for example, is resident at Bermuda (lat. 32° N.).

According to Alexander and other observers, the tropic birds nest in fissures of the cliffs on many of the islands. The bulk of them, however, doubtless dwell at the Rombos Islets, where Alexander (1898, pp. 96, 97) on March 15 found "*Phaëthon æthereus* breeding in small numbers in suitable holes and clefts among different portions of the rocks. On that particular day, when the sea wore but a darker tone than the sky, it was a pretty sight to watch these birds taking wide graceful circuits from their nest-holes out across the sea, the glossy white of their plumage at once striking the eye, while their two long rectrices, like slender pennons, streamed out behind. Both sexes incubate, and while the female is sitting the male will often sit alongside to keep her company. Towards sundown these birds congregated over some favourite spot and indulged in nuptial flights, at times circling high in the air and uttering the whole while a series of harsh screeching notes that bore a striking resemblance to those of the Common Tern during the breeding-season."

Correia collected a beautiful series of tropic birds at Razo, between May 16 and 26, and at the Rombos Islets, between June 17 and July 3. He obtained also eggs and young at both localities. The chick of this species, as is well known, passes from the nestling down, which is white on the ventral surface and smoky gray above, to a plumage similar to that of the adult.

Most of the Cape Verde breeding specimens are in rather worn plumage, which gives them a relatively dark-backed appearance, abrasion of the white edgings of the dorsal plumage tending to expose the blackish bars of underlying feathers. The long middle rectrices, however, are in most instances well developed, both plumes often being intact. In one male bird the longer of the two has the exceptional length of 700 mm., or more than twenty-seven and one half inches.

Measurements of thirty adult tropic birds in Correia's series show that the sexes are approximately alike in size as in appearance, the males averaging a shade the larger.

15 males.—Wing, 288–310 (299.6); first lateral feathers of tail, 97–118 (108.9); longer of middle tail feathers, 414–700 (607); exposed culmen, 61–69 (64.5); tarsus, 27–30 (29); middle toe with claw, 44–48 (45.8 mm.).

15 females.—Wing, 283–310 (297.9); first lateral feathers of tail, 94–113 (104.6); longer of middle tail feathers, 437–598 (515.1); exposed culmen, 59–67 (62.9); tarsus, 27–30 (28.6); middle toe with claw, 45–48 (46.2 mm.).

Twenty-two eggs (Fig. 9) exhibit great variation in form as well as in the amount and distribution of the purplish or chocolate pigment. Some are very finely mottled, others coarsely blotched. One egg has the principal deposit of coloring matter in the form of a broad ring around the smaller end. A belt or patch of pigment at the larger end is, of course, more common. Six examples, selected for variety, measure as follows: 43×64 , 45×62 , 41×55 , 43.5×56 , 44×66 , 40×59 mm.

Correia's field notes on *Phaëthon æthereus*, at the Cape Verde Islands, are as follows.

The tropic bird or marlin-spike is known to the Cape Verders as the *rabo de junco* (rush-tail), although the fishermen of Brava usually abbreviate this to *junco*. On the island of Sal is a small haven named after the species, and called Porto do Rabo de Junco.

About their breeding grounds the juncos nearly always travel in pairs or in greater numbers. After returning from a feeding trip at sea, they fly back and forth in front of their rocky homes for an hour or so, and finally alight to rest. The juncos usually go to sea very early in the morning, long before sunrise.

I found the larger of the Rombos Islets to be headquarters for the great majority of the juncos. At daybreak there is generally not a bird to be seen on or near the breeding grounds, but about eight o'clock they begin to return from the ocean. They

fly straight to their respective clefts or cavities in the cliff but, instead of alighting, they poise a while in air with the feet and tail trailing, and then wheel and describe short circles very rapidly, after which they return to the nest-site and poise once more. They seem to be suspicious one of another. A bird which has alighted makes loud outcries and attempts to peck any other bird which shows that it would like to descend near the same place. Should the approaching bird actually perch, the other flees from his post.

The male juncos also appear to be very jealous of their mates. If a strange male approaches a niche in which a female is brooding, the mate of the sitting bird promptly takes the invader to account, with ear-splitting calls.

The rabo de junco nests in any natural hole or cavity which affords shelter, never undertaking any construction nor bringing a nest-lining. Only one egg is laid, and, as I found young in all stages of growth along with the eggs, I came to the conclusion that the juncos breed at every season of the year. This supposition was confirmed by the local fishermen, who told me that junco eggs could be found on the island during every month. The fishermen know the breeding habits all too well, for they are the birds' worst enemies. At first I could not account for the hundreds of heads and wings of tropic birds scattered over the islands, but later I found that the fishermen come frequently to get these birds together with boobies. They pluck and draw the bodies, salt them inside and out and then hang them in the sun to cure. Hundreds of juncos are thus destroyed every year.

The juncos dive deep for the fish upon which they feed, and they remain several seconds under water, finally emerging with a fish crosswise in the beak or half swallowed.

The young of this species are hatched in light gray down, quite unlike the condition of the naked booby chicks, and this down gives place to plumage of the adult type. The feet and the bill change color with growth, the cream-colored bill of the young nestling becoming red, and the distal part of the feet turning black. The feet are small and weak, even in adults, and the juncos neither walk nor stand up. On the contrary they rest with their breasts on the ground, and when they progress over the short distances between the nest chamber and the jumping-off place, they push along on their bellies.

***Fregata magnificens* ? subspecies**

Tachypetes aquila KEULEMANS, p. 373.

Fregata aquila ALEXANDER, p. 117, etc.; SALVADORI, p. 309.

LOCAL NAMES.—*Rabo-forcado, rabil, guincho.*

A permanent resident, recorded from Santo Antão, São Vicente, São Nicolau, Boa-Vista, and São Thiago.

Keulemans states that at the time of his visit the man-o'-war birds were common in the harbor of Porto Grande, where they could be seen robbing the boobies and using the Bird Rock as a convenient resting place.

Alexander states that the only breeding station of this species among all the Cape Verde Islands is on a small islet opposite Sal Rei, Boa-Vista.

Unfortunately, Correia obtained no specimens. The status of the Cape Verde Island *Fregata* has never been fully determined. Rothschild (1915, Novit. Zool., XXII, pp. 145, 146) tentatively considered the bird as an endemic race of *F. magnificens*, but left the matter open for further investigation. Mathews' subsequent discussion (1915, 'Birds Austral.,' IV, p. 280) has shed no additional light upon its relationships with the various forms of *F. magnificens*, or with *F. aquila* of Ascension Island.

The man-o'-war bird, whatever its status may prove to be, finds at the Cape Verdes its most northerly breeding grounds in the eastern Atlantic. No member of the genus has been recorded from the Canary Islands.

Ardea cinerea cinerea

Ardea cinerea LINNÆUS, 1758, 'Syst. Nat.,' I, p. 143 (Sweden); ALEXANDER, p. 118, etc.

LOCAL NAME.—*Garça*.

A winter visitor, recorded from Santo Antão, São Vicente, São Nicolau, and São Thiago.

Pyrrherodia purpurea purpurea

Ardea purpurea LINNÆUS, 1766, 'Syst. Nat.,' I, p. 236 (France); ALEXANDER, p. 118, etc.

LOCAL NAME.—*Garça*.

A winter visitor, recorded from São Vicente and São Thiago.

Egretta garzetta garzetta

Ardea Garzetta LINNÆUS, 1766, 'Syst. Nat.,' I, p. 237 ("Habitat in Oriente").

Ardea garzetta ALEXANDER, p. 117, etc.

Herodias garzetta SALVADORI, p. 307.

LOCAL NAMES.—*Lavadeira, garça branca*.

A permanent resident, recorded from Santo Antão, São Vicente, Santa Luzia, Razo, São Nicolau, Boa-Vista, and São Thiago.

Alexander records a breeding station in Tarrafal Bay, São Nicolau, where he found the nests of nine pairs on April 24, 1897, and a colony of fifteen pairs on Boa-Vista. He also reports seeing a flock of five hundred of these egrets on Razo.

That this heron sometimes lives as a semidomesticated captive about the homes of the Cape Verders is indicated by Lady Brassey's reference to a "washerwoman-bird" (*lavadeira*) at Tarrafal Bay, Santo Antão—"a kind of white crane, who appeared quite tame, playing about

just like a kitten, pecking at the clothes or the women's feet, and then running away and hiding behind a tree." ('Around the World in the Yacht 'Sunbeam,' 1883, p. 33).

Six adults in high plumage were collected by Correia at Razo and Santa Luzia between May 16 and 23, 1922. Their dimensions are rather small, but within the ranges given by Hartert ('Vögel paläarkt. Fauna').

Correia reports that the *lavadeiras* occur everywhere in the archipelago, but in greatest abundance upon Santa Luzia. They feed, he says, mostly on small fish trapped in pools by the receding tide, while at high tide the herons, which are rather wary, may usually be seen resting on rocks a short distance off shore. Similar situations are chosen for the nests, which are constructed of twigs and drift material, so that they look like jetsam.

Two eggs, according to Correia, ordinarily constitute the full set. A pair from Santa Luzia are pale greenish blue. One is considerably more pointed than its mate, but the measurements are nearly the same, viz., 32.2×44 and 32.6×43.5 mm.

Bubulcus ibis ibis

Ardea Ibis LINNÆUS, 1758, 'Syst. Nat.,' I, p. 144 (Egypt).

Bubulcus lucidus SALVADORI, p. 308.

A resident, recorded from Boa-Vista and São Thiago.

Comatibis eremita

Upupa Eremita LINNÆUS, 1758, 'Syst. Nat.,' I, p. 118 (Switzerland).

Comatibis comata SALVADORI, p. 307.

A rare or casual visitor, recorded from Boa-Vista.

Phænicopterus antiquorum

Phænicopterus antiquorum TEMMINCK, 1820, 'M. d'Orn.,' II, p. 587 (Europe); KEULEMANS, p. 372.

Phænicopterus roseus ALEXANDER, p. 117, etc.; SALVADORI, p. 309.

LOCAL NAME.—*Flamingo*.

A permanent resident, recorded from Sal, Boa-Vista, and Maio.

Bolle states that the breeding grounds of the flamingo on the easterly islands were well known to early Dutch sailors, and that a raid upon one of them is described by Dampier. According to Keulemans, the young are still eaten by the Cape Verders, who also sometimes rear them in captivity.

The following quotation is taken from Alexander's account (1898, pp. 110, 111) of his visit to Boa-Vista:

“On May 13th [1897] we made our first attempt to approach the Flamingoes, which frequent a series of brackish pools close to the sea and not far from the village of Estenço Velho. The road thither being anything but good, we made use of our schooner, to get there. Towards the evening we landed and were met by a guide, who undertook to take us to the locality. On the way we happened to look seaward, and there, to our great satisfaction, caught sight of a party of Flamingoes coming towards the brackish pools; not in any wedge-shaped formation, but in a long, even line. They settled in open order, their backs towards the sea, preened their feathers, and then commenced to feed, without changing their position. Our guide mumbled a prayer in his hat; a minute later, however, they saw us, and then a slow march towards a common base, where their leader stood erect, was executed, a manœuvre soon followed by a general uprising amid goose-like croaks. In the middle distance the white of their plumage disappeared, leaving visible only the rose-coloured bands on their wings, like a long streak of feathery cloud at sunset. Soon their white plumage showed out again as they steered once more towards the sandy coast, where a general settling took place some two miles ahead of us.”

Nettion crecca crecca

Anas Crecca LINNÆUS, 1758, ‘Syst. Nat.,’ I, p. 125 (Sweden).

Nettion crecca SALVADORI, p. 310.

LOCAL NAME.—*Marreca*.

A winter visitor, recorded from Boa-Vista.

Marmaronetta angustirostris

Anas angustirostris MÉNÉTRIES, 1832, ‘Cat. Rais. Caucase,’ p. 58 (Lenkoran).

Marmaronetta angustirostris ALEXANDER, p. 117, etc.; SALVADORI, p. 310.

A resident species, recorded from Boa-Vista.

Nyroca ferina ferina

Anas ferina LINNÆUS, 1758, ‘Syst. Nat.,’ I, p. 126 (Sweden).

Nyroca ferina SALVADORI, p. 310.

A winter visitor, recorded from São Nicolau.

Nyroca nyroca nyroca

Anas nyroca GÜLDENSTÄDT, 1769, Nov. Comm. Sc. Petropol., XIV, part I, p. 403 (South Russia).

Nyroca africana SALVADORI, p. 310.

A winter visitor, recorded from Boa-Vista.

Neophron percnopterus percnopterus

*Vultur Perenopterus*¹ LINNÆUS, 1758, 'Syst. Nat.,' I, p. 87 (Egypt).

Neophron percnopterus ALEXANDER, p. 114, etc.; SALVADORI, p. 286.

LOCAL NAMES.—*Abutre, passaro branco* (São Vicente), *mignato* (São Thiago), *canhota, Manoel Lobo* (Brava).

A permanent resident, recorded from São Vicente, Santa Luzia, São Nicolau, Boa-Vista, São Thiago, Fogo, Brava, and the Rombos Islets.

At the Cape Verdes the "Pharaoh's chicken" reaches the western limit of its range. Bolle states that this vulture is found throughout the islands, in the valleys of the interior as well as on the coast. It is always in evidence about the settlements of fishermen, and among garbage dumps on the outskirts of towns.

Dohrn records that its numbers vary noticeably with the numbers of live-stock; after long periods of drought and famine the vultures, like the cattle and poultry, become relatively scarce.

An adult male, one of a dozen or more seen, was collected by the writer at Porto Grande, São Vicente, on September 17, 1912.

Alexander (1898, p. 77) writes of this species at São Thiago: "Around the outskirts of the town, numbers of Egyptian Vultures, all adult birds, sat hunched up on the boulders that strew the plain, choosing, however, stones as far apart as possible one from another—as if a quarrel had taken place between them, resulting in a mutual coolness. These birds find plenty of food in Praya. Every morning, as regularly as clockwork, they used to troop over the town on their way to the slaughter-house that lies a little back from the quay, in order to gorge themselves on the offal. Then they would return the same way, but a little slower this time, to their old place of meeting beyond the town, where they remained inert throughout the heat of the day."

Buteo buteo bannermani

Buteo buteo bannermani SWANN, 1919, 'Synopt. List. Accipitres,' p. 44. (Near Mindello Bay, São Vicente, Cape Verde Islands.)

Buteo vulgaris ALEXANDER, p. 115, etc.

LOCAL NAME.—*Milhafre*.

An endemic subspecies, recorded from São Vicente, Boa-Vista and São Thiago.

The type is a female in the British Museum. Swann's description of the race was based upon only a single skin. This buzzard is, however,

¹The original misspelling of the specific name has been generally accepted as a type-setter's error.

not uncommon and is one of the elements of the avifauna which has led Alexander and other observers to remark upon the extraordinary numbers of birds of prey to be found in the archipelago.

Cerchneis tinnuncula neglecta

Falco neglectus SCHLEGEL, 1873, 'Mus. Pays-Bas Rev. Ois. de Proie, Accipitres,' p. 43 (São Vicente, Cape Verde Islands); ALEXANDER, p. 115, etc.

Tinnunculus neglectus SALVADORI, p. 286.

LOCAL NAMES.—*Falcão, francelho, Zabelinha, peleli.*

An endemic subspecies, recorded from Santo Antão, São Vicente, Razo, São Nicolau, Boa-Vista, Maio, São Thiago, and Brava.

This native kestrel is so common and conspicuous that it figures in the island folklore. Dohrn records that the *Zabelinha* ("Little Isabella") was originally a pretty maiden, who was so inordinately fond of dancing that she was transformed into a hawk.

Keulemans states that the kestrel is particularly abundant in the mountains and near towns, that it breeds among rocks in January, and that it feeds upon grasshoppers, butterflies, beetles, mice, and small birds.

Two specimens were collected at Razo by Correia. The measurements are as follows:

	Wing	Tail	Tarsus
♂ ad., May 18, 1922	192	123	42.0 mm.
♀ ad., May 22, 1922	205	131	42.5

Alexander (1898*a*, p. 278) believed that the "southern islands of the archipelago, especially Santiago and Maio, possess a larger form of this Kestrel," and that typical *neglecta* is confined to the northerly islands.

The following is translated from Correia's field notes.

These small hawks spend most of their time seeking out lizards among the stones. They feed more upon lizards than anything else. They make a nest of dry grasses among crevices of the rocks, and lay three eggs. The natives of São Vicente and São Nicolau call this hawk *passarinho*, the same term of familiarity by which the inhabitants of the southern islands know the kingfisher. On São Thiago it is known as *falcãozinho*, and on Fogo and Brava as *peleli*.

Accipiter melanoleucus

Accipiter melanoleucus SMITH, 1830, South Afr. Quart. Journ., (1), p. 229 (Bavians River, Cape Province); WALLACE, p. 215.

An accidental visitor.

The black sparrow hawk, an Ethiopian form included in Wallace's list of the birds of the Cape Verdes, has not since been recorded from the

islands. The doubts have recently been cleared by Bannerman (1922, *Revue Zoologique Africaine*, X, fasc. 2, p. 173) who states that *Accipiter melanoleucus* is represented in the British Museum by a specimen taken at sea off the Cape Verde Islands. This hawk should, therefore, be considered as only a casual or accidental element of the fauna.

Circus pygargus

Circus Pygargus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 89 (England).

Montagu's Harrier, ALEXANDER, p. 284.

Circus cinerarius SALVADORI, p. 311.

A winter visitor, recorded from Branco.

Milvus migrans migrans

Falco migrans BODDAERT, 1783, 'Tabl. Planch. Enlum.,' p. 28 (France).

Milvus regalis KEULEMANS, p. 364; DOHRN, p. 3.

Milvus iclinus WALLACE, p. 215.

Milvus migrans ALEXANDER, p. 115, etc.

Milvus korschum MOSELEY, 1879, 'Notes Nat. 'Challenger,' p. 55.

LOCAL NAME.—*Milhafre*.

A permanent resident, recorded from Santo Antão, São Vicente, Razo, São Nicolau, Boa-Vista, São Thiago, Brava, and the Rombos Islets.

Keulemans found this kite rather scarce in most of the islands, but common on São Nicolau, where it was an injurious bird, feeding largely upon young poultry. The same author states that the kites fly much along the coast, and that they not infrequently catch fish.

Moseley records the following notes, made in the harbor of Porto Praya, São Thiago, on August 7, 1873:

"As the ship came to anchor, a flock of kites (*Milvus korschum*) came wheeling round the stern, just as do gulls ordinarily, and keep swooping down after garbage from the ship. Instead of seizing the morsels with their beaks, like gulls, they did so with their claws, putting out one foot for the purpose as they swooped down, and seizing the food with it with wonderful precision. As they rose they bent down their heads and ate the food at once on the wing from their claws. Some large fish came round the ship, and amongst them some sharks, one of which was seen to seize one of the kites as it put its foot down to the water and carry it down after a short struggle."

Alexander (1898, p. 76) gives a vivid description of a similar scene.

Natives of São Vicente, São Nicolau, and Brava independently told the writer a weird tale about this bird, one which evidently finds con-

siderable credence in the islands. This was to the effect that the kite has a knife-like breastbone which projects beyond the feathers, and that with this weapon it decapitates poultry, leaving the heads on the ground while it carries off the body!

Pandion haliaëtus haliaëtus

Falco Haliaëtus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 91 (Sweden).

Pandion haliaëtus ALEXANDER, p. 115, etc.; SALVADORI, p. 287.

LOCAL NAMES.—*Guincho*, *Manoel Lobo* (São Thiago), *minhoto gaivota*.

A permanent resident recorded from Santo Antão, São Vicente, Branco, Razo, São Nicolau, Sal, Boa-Vista, São Thiago, and Brava.

The osprey reaches at the Cape Verdes the southeastern limit of its Old World breeding range. It apparently occurs on all of the islands, but is particularly common, according to Bolle, on the low, easterly islands of Sal and Boa-Vista, and upon the Desertas. Alexander reports that São Nicolau is also a favorite resort of this bird.

Keulemans states that the ospreys may often be seen soaring in groups of from three to six, that they feed upon mice (!) as well as fish, and that their breeding season extends from January to April. The same author says that many of the inhabitants call this hawk "gaivota," the Portuguese word for gull.

An adult male, with a white head, was collected by Correia at Brava on July 3, 1922. His field notes state:

The *guincho*, as it is called by the Cape Verders, rarely leaves the seashore. When it wishes to rest, it alights on any jutting rock, or on the ground, but never far from the beach. It is a difficult bird to approach. During its smooth, slow flight it seems to stop from time to time as though it were observing fish below. Unlike any sea bird, it picks the meat from the fish which it captures, never swallowing any of the bones. It spends the night on highlands near the coast, making its nest on the ground in similar inaccessible places. Some of the nests which I found during May contained but one egg. The *guincho's* iris is yellow and its feet are blue.

Numida galeata galeata

Numida galeata PALLAS, 1767, 'Epic. Zool.,' I, fasc. 4, pp. 13-15 (no locality).

Numida meleagris KEULEMANS, p. 371; DOHRN, p. 7; WALLACE, p. 215; ALEXANDER, p. 116, etc.; SALVADORI, p. 298.

LOCAL NAME.—*Gallinha do matto*.

An introduced bird, recorded from Santo Antão, São Vicente, São Nicolau, São Thiago, Brava, and Fogo.

Pallas applied the name *galeata* to the domesticated Guinea fowl of Europe. As the type locality of the wild form has apparently never been

fixed, I would suggest Bathurst, at the mouth of the River Gambia, where specimens have been collected by Moloney.

Bolle speaks of large numbers of Guinea fowls inhabiting the heights of Santo Antão. Keulemans found them common on the precipitous hillsides of all the inhabited islands, especially in inaccessible localities. In São Thiago, he states, they are more abundant than elsewhere, occurring in the lowlands as well as the hills. Keulemans further reports that these birds breed in October and later, and that they are extremely wary. They rarely fly, but when suspicious of danger they run rapidly to a place of concealment, from which they can be flushed with difficulty.

The following is quoted from Moseley ('Notes Nat. 'Challenger,' 1879, p. 57), and refers to the Guinea fowl of São Thiago.

"We met with several flocks of wild galinis, which are abundant on the island, but are very difficult to approach. The birds inhabit the slopes of the gorges which are covered with a thick growth of oil trees (*Jatropha curcas*) which have very much the habit and general appearance of castor-oil plants. The flocks of galinis station sentries to keep a look-out from some rocky eminence, and these, when once they have discovered an enemy, never lose sight of him, but carefully watch the stalking operations of a sportsman and give warning as soon as he gets too near to their comrades and is just expecting to get a shot."

Coturnix coturnix coturnix

Tetrao Coturnix LINNÆUS, 1758, 'Syst. Nat.,' I, p. 161 (Sweden).

Coturnix communis ALEXANDER, p. 88, etc.; CASSIN, 1858, 'U. S. Expl. Exp.,' VIII, p. 288.

LOCAL NAME.—*Codorniz*.

A migrant visitor, recorded from São Vicente, Boa-Vista, São Thiago, and Brava.

Although Hartert ('Vögel paläarkt. Fauna,' III, p. 1942) states that the endemic race of *Coturnix coturnix* is the only quail of the Cape Verde Islands, there can be little doubt that the numbers of the resident birds are swelled at certain seasons by bands of the European migratory quails on their autumn flight. Bolle reports that the islands are a favorite stopping place for migrant quails, and Moseley ('Notes Nat. 'Challenger,' 1879, p. 54) writes: "At the periods of migration, quails are extremely abundant on the island [São Vicente], as at St. Jago, and often afford good sport to naval officers; they are, however, mere birds of passage here, and there were none at the time of our visit." (August 5.)

Alexander (1898, p. 88) writes as follows:

"We rarely met with the red-throated resident form of Quail, *C. capensis*, and the only specimen of it obtained could not be preserved. We often found migrants of the Common Quail, and always in exactly the same spots. We killed more than a dozen of these, and all were females, from which we are inclined to think that the sexes of this species on migration keep apart. Quails are not so numerous as they used to be. The Governor-General, who is a keen sportsman, told me that four years ago it was not an unusual thing to go out and get thirty brace in a day. The present scarcity is no doubt due to the lack of food, consequent on there having been no rain for the last three years."

Coturnix coturnix inopinata

Coturnix coturnix inopinata HARTERT, 1917, 'Nov. Zool.,' p. 422 (Cape Verde Islands).

Coturnix communis KEULEMANS, p. 370; SALVADORI, p. 298.

Coturnix capensis ALEXANDER, p. 116, etc.

LOCAL NAME.—*Codorniz*.

An endemic subspecies, recorded from Santo Antão, São Vicente, São Nicolau, Boa-Vista, São Thiago, Fogo, and Brava.

Keulemans states that the native quail is particularly abundant upon São Nicolau, and that its breeding season commences in October.

In W. Winwood Reade's 'Savage Africa,' 1864, p. 303, is an account of a quail hunt on São Nicolau, included within a chapter of interesting information about the Cape Verde Islands.

Gallinula chloropus chloropus

Fulica Chloropus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 152 (England).

Gallinula chloropus SALVADORI, p. 301.

LOCAL NAME.—*Galeirão*.

A winter visitor, recorded from Boa-Vista.

Bolle found these birds in numbers during December, 1852, in lagoons of Boa-Vista, where Fea later collected specimens.

Arenaria interpres interpres

Tringa Interpres LINNÆUS, 1758, 'Syst. Nat.,' p. 148 (Gothland, Sweden).

Arenaria interpres SALVADORI, p. 299.

Strepsilas interpres ALEXANDER, p. 118, etc.

LOCAL NAME.—*Maçarico*.

A winter visitor, recorded from Santa Luzia, São Nicolau, Razo, Boa-Vista, and the Rombos Islets.

A female was obtained by Correia at Santa Luzia on May 28, 1922.

Charadrius alexandrinus alexandrinus

Charadrius alexandrinus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 150 (Egypt).

Ægialitis cantiana ALEXANDER, p. 116, etc.; SALVADORI, p. 299.

LOCAL NAME.—*Tarambola*.

A permanent resident, recorded from São Vicente, Sal, Boa-Vista, and São Thiago.

Squatarola squatarola squatarola

Tringa Squatarola LINNÆUS, 1758, 'Syst. Nat.,' I, p. 149 (Sweden).

Squatarola helvetica ALEXANDER, p. 118, etc.

LOCAL NAME.—*Morinello*.

A migrant visitor, recorded from Boa-Vista.

Recurvirostra avosetta

Recurvirostra Avosetta LINNÆUS, 1758, 'Syst. Nat.,' I, p. 151 (Oeland).

Recurvirostra avocetta ALEXANDER, p. 285.

A migrant visitor, recorded from Maio.

Limosa limosa limosa

Scolopax Limosa LINNÆUS, 1758, 'Syst. Nat.,' I, p. 147 (Sweden).

Black-tailed Godwit, ALEXANDER, p. 285.

Limosa belgica SALVADORI, p. 311.

A migrant visitor, recorded from Boa-Vista.

Totanus totanus totanus

Scolopax Totanus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 145 (Sweden).

Totanus calidris SALVADORI, p. 300.

A migrant visitor, recorded from Boa-Vista.

Totanus nebularius

Scolopax nebularia GUNNERUS, 1767, in Leem, 'Beskr. Finm. Lapp.,' p. 251 (Norway).

Totanus glottis ALEXANDER, p. 118, etc.; SALVADORI, p. 300.

A migrant visitor, recorded from Boa-Vista and São Thiago.

Rhyacophilus glareola

Tringa Glareola LINNÆUS, 1758, 'Syst. Nat.,' I, p. 149 (Sweden).

Totanus glareola SALVADORI, p. 300.

A migrant visitor, recorded from Boa-Vista.

Actitis hypoleucos

Tringa Hypoleucos LINNÆUS, 1758, 'Syst. Nat.,' I, p. 149 (Sweden).

Tringoides hypoleucus ALEXANDER, p. 118, etc.; SALVADORI, p. 300.

A migrant visitor, recorded from São Thiago and Brava.

Canutus canutus canutus

Tringa Canutus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 149 (Sweden).

Tringa canutus ALEXANDER, p. 285.

A migrant visitor, recorded from Maio.

Pelidna alpina alpina

Tringa alpina LINNÆUS, 1758, 'Syst. Nat.,' I, p. 149 (Lapland).

Dunlin, ALEXANDER, p. 285.

Pelidna alpina SALVADORI, p. 311.

A migrant visitor, recorded from Boa-Vista.

Erolia ferruginea

Tringa Ferruginea BRÜNNICH, 1764, 'Orn. Bor.,' p. 53 (Iceland and Christiansoë).

Ancylocheilus subarquatus SALVADORI, p. 300.

A migrant visitor, recorded from Boa-Vista and Maio.

Crocethia alba

Trynga alba PALLAS, 1766, 'Vroeg's Cat.' (Adumbratiuncula), p. 7 (Coast of North Sea).

Calidris arenaria ALEXANDER, p. 118, etc.; SALVADORI, p. 300.

A migrant visitor, recorded from São Vicente, Sal, and Boa-Vista.

Numenius arquatus arquatus

Scolopax Arquata LINNÆUS, 1758, 'Syst. Nat.,' I, p. 145 (Sweden).

Numenius arquatus ALEXANDER, p. 118, etc.

LOCAL NAME.—*Maçarico real*.

A migrant visitor, recorded from Sal, Boa-Vista, Maio, and São Thiago.

Numenius phæopus phæopus

Scolopax Phæopus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 146 (Sweden).

Numenius phæopus ALEXANDER, p. 118, etc.; SALVADORI, p. 299.

LOCAL NAME.—*Maçarico real*.

A migrant visitor, recorded from Santo Antão, São Vicente, Santa Luzia, Razo, São Nicolau, Sal, Boa-Vista, and São Thiago.

Adult females were collected by the writer at São Vicente on September 16, 1912, and by Correia at Razo on May 16, 1922.

Glareola pratincola pratincola

Hirundo Pratincola LINNÆUS, 1766, 'Syst. Nat.,' I, p. 345 (Austria).

Glareola pratincola SALVADORI, p. 299.

A migrant visitor, recorded from São Thiago.

Cursorius cursor exsul

Cursorius gallicus exsul HARTERT, 1920, 'Vög. paläarkt. Fauna,' II, p. 1526 (Cape Verde Islands).

Cursorius gallicus ALEXANDER, p. 115, etc.

LOCAL NAME.—*Corredeira*.

An endemic subspecies, recorded from São Vicente, Santa Luzia, Razo, Sal, Boa-Vista, and São Thiago.

Eight specimens were obtained by Correia at Razo and São Vicente during May 1922. The series, which includes nestlings, shows that as the down is molted the chicks acquire a plumage substantially like that of the adult, but lacking the gray pileum. The first plumage of the chest and the entire upper surface, moreover, is marked with dark, wavy, subterminal bars, which are subsequently lost through abrasion. The primary quills of the young are black like those of the adult.

The following is translated from Correia's field notes:

I saw these birds mostly on São Vicente, on the plain which lies south of the city and stretches toward São Pedro. This sandy region is more or less covered with leafless stalks of dead vegetation, and here small bands of *corredeiras* could be seen flying about or running very rapidly, though for only short distances. The native people say that they nest in sandy places where there is more or less grass, and that sometimes as many as ten eggs have been found in one nest.

Rissa tridactyla tridactyla

Larus tridactylus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 136 (Great Britain).

Rissa tridactyla ALEXANDER, p. 118, etc.

LOCAL NAME.—*Gaivota*.

A winter visitor, recorded from Brava.

Larus fuscus atlantis

Larus fuscus atlantis DWIGHT, 1922, Amer. Mus. Novit., No. 44, p. 1 (Fayal, Azores).
Lesser black-backed Gull, ALEXANDER, p. 284.

LOCAL NAME.—*Gaivota*.

A winter visitor, recorded from Boa-Vista.

Dr. Jonathan Dwight has identified at the British Museum an adult specimen of this gull collected at the Cape Verdes in June 1901.

It is not likely that this Atlantic Island race breeds at the Cape Verde Islands, but it doubtless makes at least a partial migration from the more northerly groups.

Columba livia subps. (?)

Columba livia ALEXANDER, p. 116, etc.; SALVADORI, p. 297.

LOCAL NAMES.—*Pomba da rocha*, *pomba brava*.

An introduced species, recorded from São Nicolau and São Thiago.

Rock pigeons were living wild along the cliffs at São Thiago as early as the date of Bolle's paper (1856). Moseley also refers to their abundance in the cultivated fields of the main valley of this island.

Cuculus canorus subsp. (?)

Cuculus canorus SALVADORI, p. 297.

A winter visitor, recorded from Brava.

In default of specimens, it is impossible to determine whether the cuckoo recorded by Salvadori is of the typical north European race or the Spanish form, *C. c. bangsi* Oberholser (*C. c. minor* A. E. Brehm), which has been taken at Tenerife and Madeira.

Eurystomus afer afer

Coracias afra LATHAM, 1790, 'Ind. Orn.,' p. 172 (Africa).

Eurystomus afer ALEXANDER, p. 285.

A casual visitor, recorded from Maio.

Halcyon leucocephala acteon

Dacelo acteon LESSON, 1831, 'Traité d'Orn.,' p. 247 (Cape Verde Islands).

Dacelo rufiventris KEULEMANS, p. 366.

Halcyon rufiventris DOHRN, p. 4.

Halcyon erythrorhyncha WALLACE, p. 215.

Halcyon erythrogaster ALEXANDER, p. 116, etc.

LOCAL NAME.—*Passarinha*.

An endemic subspecies, recorded from São Thiago, Fogo, and Brava.

The kingfisher is confined to the southerly islands where, according to all observers, it is a great favorite with the inhabitants, notwithstanding a legend, recorded by Keulemans, that it "picks out the eyes of young chickens." Perhaps in consequence of the favor it has found, it is one of the tamest of Cape Verde species.

The breeding season, according to Keulemans and Dohrn, commences in December, the birds nesting in hollows among the exposed roots of trees. The kingfisher's food comprises grasshoppers, butterflies, lizards, and even mice. It has the habit of using the same perch for long periods, darting forth like a flycatcher in pursuit of its prey and then returning. This trait was noted also by Alexander, who has given a charming account of the species (1898, pp. 87, 88).

Keulemans writes that the young are slow to acquire their full growth, even after they fly, and that the adult birds are long distinguishable by their larger size and richly-colored bills. He states further that the flight note is a loud, laughing cry, similar to that of the native kestrel

(*Cerchneis*). Moseley describes its call as “a terribly harsh laughing cry, a feeble imitation of that of its congener of Australia, the laughing jackass.”

Male and female adults were collected by Correia at Brava on June 14, 1922. The collector’s field notes report:

This, the prettiest bird which I saw in the Cape Verdes, is protected by the sentiment of the inhabitants because of its beauty and inoffensiveness. The kingfishers are usually seen alone; in fact, I have no recollection of finding even two in the open together. They nest always in low places, such as holes in stone walls or the spaces among piles of earth and small stones. The nest itself is a ball of dry grass or similar material, completely filling the occupied cavity. They lay two eggs, but rarely hatch out more than one chick. The people of Brava believe that the kingfishers live only one year. They declare, moreover, that these birds are so weak and timid that the report of a gun close by is enough to cause them to fall to earth.

This kingfisher is a large-billed, island form of *Halcyon leucocephala*, which is found throughout the savanna regions of Africa and southern Arabia. Compared with specimens of the typical race collected by Dr. J. P. Chapin in the Uelle district of the northern Congo, the hue of the wings, rump and tail of the Cape Verde birds is of a distinctly deeper, less greenish blue. At the same time the color, particularly of the rump, is not nearly so dark and violaceous as in *H. l. swainsoni*, of which we have skins from the Kasai district of the southern Congo. The latter subspecies has, moreover, only cinnamon-rufous flanks and abdomen.

The ranges of these two mainland races, *leucocephala* and *swainsoni*, are separated by the equatorial forest. In East Africa, even the equatorial districts are occupied by the species, because of the lack of heavy forest, and the birds found there, which are referred to the races *hyacinthina* and *centralis*, combine the deep chestnut belly of *H. l. leucocephala* with a somewhat deeper blue on wings, rump, and tail.

Most recent authors have followed Claude Grant’s revision of these kingfishers (Ibis, 1915, pp. 265–267), but Dr. Chapin considers the form *H. l. ogilviei* as synonymous with *hyacinthina*.

				LENGTH OF CULMEN	DEPTH OF BILL AT BASE	WIDTH OF MAXILLA AT BASE
<i>Halcyon leucocephala leucocephala</i>	♂			44.0	11.0	16.0 mm.
“ “ “	♀			45.0	11.2	17.0
“ “ <i>acteon</i>	♂			43.0	13.0	17.0
“ “ “	♀			45.5	13.0	17.8
“ “ <i>swainsoni</i>	♂			42.0	10.5	15.0
“ “ “	♀			40.0	11.0	16.5

Tyto alba detorta

Tyto alba detorta HARTERT, 1912, Bull. Brit. Orn. Club, XXXI, p. 38 (São Thiago, Cape Verde Islands).

Strix insularis ALEXANDER, p. 115, etc.; SALVADORI, p. 288.

LOCAL NAME.—*Coruja*.

An endemic subspecies, recorded from São Vicente, Razo, São Nicolau, São Thiago, and Brava.

Hartert has shown that Pelzeln's name *insularis*, previously used for this form, is applicable to the barn owl of St. Vincent, West Indies, rather than São Vicente of the Cape Verdes.

According to Keulemans, the barn owl breeds in November among crevices of the rocks.

Correia collected an adult female at Brava on July 5, 1922. His notes state:

The *coruja* conceals itself in cavities of the rocks until sunset. As the bird feeds largely upon rats, it is a favorite with the people of the islands, notwithstanding certain bad omens connected with its calling from the housetops on moonless nights. The *coruja* lays three eggs, always in some more or less dimly lighted place of concealment.

Micropus apus apus

Hirundo Apus LINNÆUS, 1758, 'Syst. Nat.,' I, p. 192 (Sweden).

Cypselus apus SALVADORI, p. 296.

A winter visitor, recorded from Fogo.

It is by no means impossible that *Micropus murinus brehmorum* also occurs at the Cape Verde Islands, or that specimens of this Madeiran form have been wrongly identified with *Micropus apus*.

Micropus unicolor unicolor

Cypselus unicolor JARDINE, 1830, Edinb. Journ. Nat. and Geogr. Sc., I, p. 242, Pl. VI (Madeira). ALEXANDER, p. 116, etc. (part).

A winter visitor, recorded from Brava and São Thiago.

This swift is the breeding form of Madeira and the Canary Islands, which winters in the Cape Verdes.

Micropus unicolor alexandri

Apus unicolor alexandri HARTERT, 1901, Nov. Zool., VIII, p. 328 (São Nicolau, Cape Verde Islands).

Cypselus unicolor ALEXANDER, p. 116, etc. (part).

An endemic subspecies, recorded from São Nicolau, São Thiago, and Brava.

Bolle, as long ago as 1856, noted the presence of *Cypselus unicolor* on São Nicolau. Alexander found this swift breeding in crevices of the rock on Brava.

Alæmon alaudipes alaudipes

Upupa alaudipes DESFONTAINES, 1787, Mém. de l'Acad., p. 504 (Gafsa and Tozer, Tunis).

Certhilauda desertorum WALLACE, p. 215.

Alæmon alaudipes ALEXANDER, p. 116, etc.; SALVADORI, p. 294.

Certhilauda alaudipes SHELLEY, 1902, 'Birds Africa,' III, p. 19.

LOCAL NAME.—*Cotovia*.

A permanent resident, recorded from Boa-Vista.

The possibility that the Cape Verde birds represent an endemic subspecies should be investigated.

Ammomanes phœnicura cinctura

Melanocorypha cinctura GOULD, 1841, 'Zool. Voy. 'Beagle,' III, Birds, p. 87 (São Thiago, Cape Verde Islands).

Alauda elegans, KEULEMANS, p. 369.

Alauda cinctura, DOHRN, p. 5.

Ammomanes cinctura, WALLACE, p. 215; ALEXANDER, p. 116, etc.; SALVADORI, p. 294.

LOCAL NAMES.—*Pastor*, *calhandra*.

An endemic subspecies, recorded from Sal, Boa-Vista, and São Thiago.

Keulemans and Dohrn report that this lark is common on São Thiago, where it forages for insects and seeds in little bands on the dry plains, often in company with *Pyrrhulauda nigriceps*. It is usually to be found in the neighborhood of grazing goats, which accounts for the name *pastor* (shepherd). It sings in flight, but does not rise as high as the European skylark. Its song, moreover, is shorter and feebler than that of its gifted relative.

Spizocorys razæ

Spizocorys razæ ALEXANDER, 1898, Ibis, p. 107, Pl. III (Razo, Cape Verde Islands).

Callandrella razæ SHELLEY, 1902, 'Birds Africa,' III, p. 137.

An endemic species, known only from Razo.

Pyrrhulauda nigriceps

Pyrrhulauda nigriceps GOULD, 1841, 'Voy. 'Beagle,' Birds,' p. 87 (Cape Verde Islands).

Pyrrhulauda crucigera KEULEMANS, p. 369.

Pyrrhulauda nigriceps ALEXANDER, p. 116, etc.; SALVADORI, p. 295; SHELLEY, 1902, Birds Africa, III, p. 81, Pl. xx.

LOCAL NAMES.—*Primo Philippe, pastor.*

A permanent resident, recorded from Santo Antão, Boa-Vista, and São Thiago.

Keulemans found these larks common on dry plains in São Thiago, usually in company with *Ammomanes*. He states that *Pyrrhulauda* does not fly high, but that it often covers long distances at a height of from ten to twenty feet, singing as it goes.

Alexander reports this lark to be more numerous on Boa-Vista than on any other island.

Sylvia atricapilla atricapilla

Motacilla Atricapilla LINNÆUS, 1758, 'Syst. Nat.,' I, p. 187 (Sweden).

Sylvia atricapilla gularis ALEXANDER, p. 81.

Sylvia atricapilla SALVADORI, p. 289.

LOCAL NAMES.—*Toutinegra, pardal rouxinol.*

A permanent resident, recorded from Santo Antão, São Vicente, São Nicolau, São Thiago, and Brava.

Bolle notes that the blackcaps are especially common on plantations, and wherever trees are cultivated. Keulemans found them most abundant on Santo Antão and São Nicolau. On the former island he discovered a nest with eggs in January, six feet from the ground in an orange tree and constructed of moss, wisps of grass, and banana fibers.

On São Nicolau, in February, Keulemans noted that all the blackcaps had their faces and throats stained yellow or orange with pollen from the aloes blossoms. The same phenomenon later misled Alexander into describing the resident Cape Verde Island blackcap as a new and highly colored subspecies!

Sylvia conspicillata bella

Sylvia conspicillata bella TSCHUSI, 1901, 'Orn. Monatsber.,' p. 130 (Madeira and the Canary Islands).

Sylvia conspicillata ALEXANDER, p. 115; SALVADORI, p. 289.

LOCAL NAME.—*Pardal d'algodoeiro.*

A permanent resident, recorded from Santo Antão, São Vicente, São Nicolau, Boa-Vista, São Thiago, Fogo, and Brava.

Keulemans reports that this species is especially common on Santo Antão and São Nicolau, and that it occurs from sea level to mountain top. He says that outside the breeding season the birds form small flocks which keep to the thickets of acacia or other vegetation. They breed in October and November, and Keulemans found a nest with five eggs in a low bush. The male sings much in flight.

A pair, apparently ready to breed, was taken by the writer in a tamarind grove near Porto Grande, São Vicente, on September 17, 1912.

Calamocichla brevipennis

Calamodyta brevipennis KEULEMANS, 1866, *Nederland. Tijdschr. Dierk.*, III, p. 368 (São Nicolau, Cape Verde Islands).

Calamorherpe brevipennis DOHRN, p. 4; WALLACE, p. 215.

Calamocichla brevipennis SALVADORI, p. 290.

LOCAL NAME.—*Pardal de Barbaria*.

An endemic species, recorded from São Nicolau, São Thiago, and Brava.

The description of this species has heretofore been credited to Dohrn, but Keulemans' designation has priority and satisfies all the technical requirements of nomenclature.

Keulemans and Dohrn found this reed warbler common on São Thiago and São Nicolau, but entirely lacking on Santo Antão and São Vicente. They state that the birds lived in the mountains, far from water, and also on sugar plantations, where they could be seen climbing the stalks of cane. They reminded the observers of the European reed warbler (*Acrocephalus arundinaceus*), except for their larger size and the fact that the song is entirely different. The voice of the male is so powerful that Keulemans, upon first hearing it, looked for a much larger bird.

An excellent account of this species is given by Alexander (1898, pp. 82, 83).

Saxicola œnanthe œnanthe

Motacilla Œnanthe LINNÆUS, 1758, 'Syst. Nat.', I, p. 186 (Sweden).

Saxicola œnanthe ALEXANDER, p. 285.

A migrant visitor, recorded from Maio.

Hirundo rustica rustica

Hirundo rustica LINNÆUS, 1758, 'Syst. Nat.', I, p. 191 (Sweden); ALEXANDER, p. 118.

LOCAL NAME.—*Andorinha*.

A migrant visitor, recorded from Santo Antão, São Vicente, Razo, and São Nicolau.

A young male came aboard the brig 'Daisy' on September 15, 1912, off Santo Antão. A second specimen, an adult male, was collected from a mixed flock of migrant swallows at São Vicente on September 17, and Correia obtained an adult female at Razo on May 18, 1922.

Delichon urbica urbica

Hirundo urbica LINNÆUS, 1758, 'Syst. Nat.,' I, p. 192 (Sweden).

Chelidon urbica ALEXANDER, p. 311.

LOCAL NAME.—*Andorinha*.

A migrant visitor, recorded from São Nicolau and Brava.

Riparia riparia riparia

Hirundo riparia LINNÆUS, 1758, 'Syst. Nat.,' I, p. 192 (Sweden).

A migrant visitor, here recorded from São Vicente, where an immature male was collected by the writer on September 17, 1912.

Corvus ruficollis ruficollis

Corvus ruficollis LESSON, 1831, 'Traité d'Orn.,' p. 329 (Cape Verde Islands).

Corvus corone KEULEMANS, p. 365; DOHRN, p. 5; WALLACE, p. 215.

Corvus umbrinus ALEXANDER, p. 115, etc.; SALVADORI, p. 288.

LOCAL NAME.—*Corvo*.

An endemic subspecies, recorded from Santo Antão, São Vicente, Razo, São Nicolau, Boa-Vista, São Thiago, Fogo, and Brava.

The raven may always be found about refuse dumps in company with the white vulture.

Keulemans states that those which he saw on Santo Antão had pronounced albinistic tendencies. Of three specimens obtained by Alexander on São Thiago, one was of "a pied variety." The same author found a nest ready for eggs on February 25.

Adults were collected at São Vicente by the writer and by Correia. The measurements follow:

	BILL	WING	TAIL	TARSUS	MIDDLE TOE AND CLAW
♂ September 17, 1912	63.0	352	181	66	53 mm.
♀ May 9, 1922	60.5	350	177	63	46

The September specimen is in fresh plumage, and the head is only slightly less black and glossy than the back. In the May bird, on the other hand, the head, neck, and upper breast are entirely cinnamon-brown, while the body is mottled with rich purplish and greenish feathers which are replacing the old and worn plumage.

The following is translated from Correia's field notes.

The raven is a repugnant and extravagant bird, seeking always places of filth where it may find something rotten to eat. Great numbers of them live in the archipelago, most of all in the island of São Vicente. The inhabitants regard them with disgust, and hold it to be bad luck when a raven crosses one's path. Because they are ignored rather than persecuted, the birds are altogether fearless, often con-

tinuing to sit in quiet melancholy while a traveler passes within three or four feet of them. Some of the inhabitants of São Vicente use them as food, especially during famine years, but only when the birds are nestlings. The ravens breed among the higher rocks, a few wisps of grass forming the nest. They lay either one or two bluish eggs.

Alexander (1898, p. 81) writes of the ravens of São Thiago:

"Locusts form the chief food of these birds, and they hunt for them in a most systematic manner. On several occasions I had the opportunity of watching them on the war-path. A party gets together and straightway sets about circumventing a portion of ground that is likely to hold locusts. Then a certain number spread themselves out like the cordon system of outposts, while the remainder, with quick strides, beat up the ground towards the locusts, which jump forward—the majority becoming the prey of the birds drawn up in line, who, carrying out the principle of "share and share alike," act in their turn as the skirmishers of the next beat."

***Estrilda astrild* subsp. (?)**

Estrela cinerea DOHRN, p. 7; WALLACE, p. 215.

Estrilda jagoensis ALEXANDER, p. 85.

Estrilda astrild SALVADORI, p. 293.

LOCAL NAMES.—*Bocca vermelha*, *gingerotte*.

An introduced bird, recorded from São Vicente, São Thiago, and Brava.

This weaver has long been acclimated at the Cape Verdes, as at St. Helena. Dohrn relates the escape at São Vicente, in March, 1865, of hundreds of captive weavers from a French bird dealer.

Estrilda astrild is now a familiar bird on the sugar plantations. It nests in November and later among the stalks of reeds or in low shrubs.

Passer jagoensis

Pyrgita jagoensis GOULD, 1837, Proc. Zool. Soc., p. 77 (São Thiago, Cape Verde Islands).

Passer erythrophrys KEULEMANS, p. 370.

Passer brancoensis OUSTALET, 1883, Ann. Sci. Nat. Zool., (6) XVI, p. 2.

Passer jagoensis ALEXANDER, p. 115, etc.; SALVADORI, p. 292.

LOCAL NAMES.—*Pardal*, *pardal de terra*.

An endemic species, recorded from Santo Antão, São Vicente, Branco, Razo, São Nicolau, Boa-Vista, São Thiago, Brava, and the Rombos Islets.

Keulemans and Dohrn state that this abundant bird breeds between November and March, making its nest either in chinks of stone walls or

in low trees such as olives. In the latter case the nests are spherical; with a lateral opening. The eggs resemble those of the house sparrow (*Passer domesticus*).

Numerous specimens were collected by both the writer and Correia. Adults taken in a copse of tamarinds near Porto Grande, São Vicente, on September 17, 1912, had enlarged gonads and seemed ready to breed, although they were still molting.

Specimens from Brava, taken in June 1922, are larger than the São Vicente birds, with longer and heavier bills, a richer chestnut on the scapulars and coverts, and a more pronounced buffy wash on the breast. The color differences may be seasonal, but it is not at all unlikely that these sparrows show true geographical variation from island to island, and that Oustalet's name may be applicable to the birds of the windward members of the archipelago.

Correia's field notes state that the sparrows sometimes cause much damage by eating young leaves as well as grain. They record also that the birds nest on the ground when trees are not available, laying three or four eggs in a structure made of cotton, hair, and dry grass.

Passer hispaniolensis hispaniolensis

Fringilla hispaniolensis TEMMINCK, 1820, 'Man. d'Orn.,' p. 353 (Gibraltar).

Passer salicarius KEULEMANS, p. 370; DOHRN, p. 6; WALLACE, p. 215.

Passer salicicola ALEXANDER, p. 115, etc.; SALVADORI, p. 291.

LOCAL NAMES.—*Pardal*, *pardal de Barbaria*.

A permanent resident, recorded from São Nicolau, Boa-Vista, São Thiago, Fogo, and Brava.

Dohrn states that the Spanish sparrow is absent from Santo Antão and São Vicente. On the southerly islands it is not rare. Keulemans writes that it begins to breed in September, making its nest usually in stone walls.

Article IV.—THE HOUSE WRENS OF THE GENUS
TROGLODYTES

BY FRANK M. CHAPMAN AND LUDLOW GRISCOM

INTRODUCTION

Of the families of birds common to both hemispheres, only the wrens are pronouncedly more abundant in the New World than in the Old, 289 species and subspecies being known from the former as compared with only 48 from the latter. We may perhaps, therefore, consider the family to be of American origin, and, if we judge by its present center of abundance, its birthplace is in the Tropics to which not less than 240 of the American forms are restricted.

In spite of their comparatively sedentary and, as a rule, non-migratory habits, several genera of wrens are notable for the extent of their range, while no other American passerine bird is found throughout a greater area than the house wren. Under this name we include the *Troglodytes aëdon-musculus* group and those insular forms which are obviously derived from it.

RELATIONS OF THE SOUTH AMERICAN AND NORTH AMERICAN FORMS.—Although the house wrens of South America and North America are considered by systematists as different species, it seems clear to us that, even if non-intergrading, they are nevertheless representative forms. It is true that the North American species possesses certain characters, notably barred flanks, which are not present in South American birds, but no one who encounters these birds in the field, whether in Patagonia or Canada or any intermediate locality, can doubt the fact of their essentially specific identity. From one end of this area to the other, when opportunity offers, they seek the haunts of man in the city, village, ranch, or farm house. Wide variation exists between the songs of various races, but there is a fundamental similarity in the character of their notes which betrays the singer's relationships, wherever he may be heard.

From the Straits of Magellan to southern Mexico, the house wren is distributed almost continuously and, with the exception of *Troglodytes tecellatus* of the Peruvian-Chilean border, our material shows the specific identity of all the continental forms inhabiting this region. The data from Mexico are too incomplete to enable us to determine the southern breeding limits of *Troglodytes aëdon*, and hence its distributional relations with *T. musculus*. In this region house wrens become migratory, and it is consequently impossible to say whether specimens from Mexico taken

out of a supposed breeding season are resident or migratory birds. *Troglodytes peninsularis* of the gulf coast of Yucatan partly bridges the gap between the *aëdon* and *musculus* types in Central America. The Mexican history of the group, however, can be written only when we are more familiar with its distribution in that country during the breeding season. Meanwhile we venture the prediction that the small gap between *musculus* and *aëdon* will be closed.

THE HOUSE WREN A SUCCESSFUL SPECIES.—Before we turn to a study of *Troglodytes musculus*, with which we are in this paper more especially concerned, we wish to call attention to certain facts common to both *musculus* and *aëdon* which it seems probable are in the main responsible for the wide range and abundance of these birds. Whether found in Argentina or British Columbia, house wrens are adaptable, aggressive, prolific birds. Any species which can closely associate itself with man is apt to find increase in its available food supply and a decrease in the number of its natural enemies. The readiness with which our house wren (*Troglodytes aëdon*) takes possession of boxes erected for its occupation, and the courage it displays in their defence, tempts the belief that the numbers of this species are limited only by the nesting-sites available for it. Ridgway¹ records the appearance of the western house wren in Illinois, where it was unknown prior to 1870, and its history there has doubtless been repeated at many other localities in recent years in response to favorable conditions. The bird is hardy and thrives in both tropical and temperate climates. Only the North American form is migratory and its journeys are not extended and are made overland.

The fertility of the northern species, which lays from six to eight eggs and raises two broods in the season, is well-known. The tropical forms² have smaller clutches but the number of eggs laid in the South Temperate Zone is apparently as large as that of the North Temperate Zone.

CENTER OF DISPERSAL OF HOUSE WRENS.—The almost continuous distribution of house wrens throughout the exceptionally wide area they inhabit, the comparatively small degree of differentiation exhibited by the continental forms, and, with but few exceptions, the intergradation of every form with its neighbors, all indicate that the characters and distribution of house wrens are, in the main, expressions of existing physiographic and climatic conditions. Nevertheless, we are unable to determine the region from which they have radiated. The absence of

¹Bull. U. S. Nat. Mus., L, part 3, p. 583.

²Three or four in Peru according to Taczanowski, and five to eight in Chile according to Reed.

the house wren as a breeding bird from at least the southern half of Florida, indicates the comparatively recent entrance of the species into America from Mexico. The difference between Mexican and Central American forms, even if the gap between them be closed, is evidence of a less close relation between these forms than that which exists between those of Central and South America. The entire absence of the family—and of any wren-like bird—from the Greater Antilles indicates the lack of wrens in Central America when that region had a closer connection with the Greater Antilles than now exists, as it is believed to have had.

If at that time Central America was separated from South America, as the senior author has before suggested,¹ the wrens or their ancestors were presumably confined to South America, whence they entered Central America subsequently to its connection with the southern continent.

All this, however, was doubtless long before the appearance of the *Troglodytes aëdon-musculus* group, which, comparatively speaking, is a group of today. It is, in short, the very fluidity of this group which makes it difficult to determine whence it has flowed. It defies climatic barriers, and seems equally at home on the plains of Argentina or Alberta, the forests of Brazil or of British Columbia. It occupies regions where rain rarely falls and others where it is of almost daily occurrence. It crosses the Andes where they are highest, and seems as much at home in the Puna or Páramo Zone as in the tropics. One can only say, therefore, that house wrens originated somewhere between Tierra del Fuego and Canada, and have extended their range both northward and southward.

THE SOUTH AND CENTRAL AMERICAN FORMS.—*Troglodytes musculus* has claimed our attention for some years, and all American Museum expeditions to the regions it inhabits have been instructed to secure representative series of it. Except at the extreme southern end of its range this species is apparently not migratory, and our series of some 600 specimens may therefore be accepted as representing the form found at the localities where they were secured.

While we are not in a position to determine the exact relations of *musculus* and *aëdon*, we believe that we can add somewhat to our recorded knowledge of the geographical variation and distribution of the first-named species, with which, indeed, this paper is chiefly concerned.

GEOGRAPHIC VARIATION IN *Troglodytes musculus*.—When one considers the great variety of environmental conditions encountered by

¹1917, Bulletin Amer. Mus. Nat. Hist., XXXVI, pp. 151–157.

Troglodytes musculus throughout a range which extends from southern Mexico to Cape Horn, it exhibits surprisingly little racial variation, in color or in size. It is true that the palest of the eighteen known forms (*striatulus* of Colombia) differs markedly from the most richly colored race (*puna* of the Peruvian tableland). But, generally speaking, the characters separating most of the recognized races are so slight that no two authors working independently would agree in the determination of the material which has served as the basis of this paper. In a number of cases racial characters become evident only when large series of specimens are examined, and they may be so overlapped by individual variation that the worker with but few specimens at his command may reach conclusions quite at variance with those here presented.

Throughout the enormous area occupied by the *albicans-clarus* group, for example, there is so little differentiation and that which exists is so obscured by individual variation that we recognize but one form from this region.

Again, the race living at the humid eastern base of the Peruvian Andes is barely separable from that occupying the arid Peruvian coast, while the two races occupying the southern one thousand miles of the continent differ only in the slightly shorter bill of the more southern race.

This condition indicates either a lack of plasticity on the part of these wide-ranging birds or a comparatively recent appearance in a large part of the area they now inhabit. When one considers the almost identical birds and the pronouncedly different habitats of the house wrens of eastern and western Peru, one is tempted to conclude that in this instance, at any rate, environment has not as yet expressed itself. It follows, therefore, that we have been unable anywhere to correlate color characters with cause. Of the two most richly colored forms, one occupies the Brazilian coast, the other the summit of the Peruvian Andes.

In size, altitude appears to exert more influence than latitude. The wing in specimens from the Magellan region agrees in size with that of Venezuelan birds, but the more southern birds have a longer tail and shorter bill, the shortest in fact of any race. But specimens from the tableland (Puna Zone) of Peru have the wing, tail, and bill larger than those from the lowland. Size, indeed, always increases with altitude, and the maximum is reached by these Peruvian birds which range higher (13,000 ft.) than any other forms.

Generally speaking, color variation is most pronounced in the underparts, which are soiled whitish in some individuals of the Colombian *striatulus* and cinnamon in the Brazilian *musculus* and Peruvian

puna. The range of color above is less wide than that below, but the rump, upper tail-coverts, and tail sometimes afford diagnostic characters. The prevailing tone above approaches Brussels-brown and varies from deeper shades of this color to a grayish drab. Not infrequently grayish individuals occur in races which are normally cinnamon-brown above. Usually this variation is seasonal, being exhibited by specimens in worn plumage. In other cases it is obviously individual and is sufficiently pronounced to suggest its being attributed to dichromatism. Variation in pattern of marking occurs in the lower tail-coverts and back. As a rule the former are barred or spotted, but in *magellanicus* these markings are usually absent. In no other instance, however, are these markings of diagnostic value.

Bars also appear on the back, but this marking is subject to wide variation and is constant in only one form, *tecellatus*, of the Peru-Chile boundary. The more southern races (*chilensis* and *magellanicus*) rarely, if ever, exhibit a trace of barring on the back, but in *striatulus* of Colombia this feature is often present and in *tecellatus* it is pronounced and constant.

THE CASE OF *Troglodytes tecellatus*.—Under the influence of the isolation afforded by the river valleys of the Peru-Chile boundary, a form of house wren has developed characters which we believe to be of specific value. While evidently the representative of *audax* at the north and of *chilensis* at the south, it apparently does not intergrade with either. Segregated in the oases of the Tarapaca desert, where its range is separated from that of the forms to the north and south by wide stretches of lifeless sand, the bird is as effectively isolated as though it occupied an island. This condition has evidently been favorable for the development of the variable, nascent back-barring, exhibited irregularly by some races, as a fixed, permanent, and conspicuous character.

This case is so exceptional and of such unusual interest in the study by environment, that we trust our interpretation of it may be tested by further field-work in the region between the known ranges of *audax* and *chilensis*. (See p. 298, footnote.)

INTERGRADATION OF RACES.—With the exception of *Troglodytes tecellatus*, we believe that every continental race of *T. musculus* intergrades with the nearest geographical ally or allies. In most cases we have specimens to prove the truth of this belief.

In only one region have we found more than one form at the same locality, the Buenos Aires region furnishing a problem through the pres-

ence there of the Patagonian, Chilean, and Uruguayan races. This case is discussed beyond.

THE ISLAND FORMS.—In spite of its non-migratory, comparatively sedentary habits, the house wren is present on some of the islands contiguous to the coast from the Falklands northward. The form on the island of Tobago (*T. musculus tobagensis*) differs from the wren of the adjacent mainland only in slightly larger size. On the Falkland Islands long isolation has produced a distinct species of house wren (*T. cobbi*), a little-known bird, which is discussed beyond. On Clarion Island of the Revillagigedo group, off western Mexico, another typical house wren (*T. tanneri*) is found, which possesses no very trenchant specific characters. While quite different in both size and color from Central American wrens of the *musculus-aëdon* group, it differs constantly from *Troglodytes musculus striatulus* only in its longer tail, a resemblance probably due to parallel development. It is of great interest, however, that it should occur on only one island in a group, many of which are in sight of one another, and that the wren of the neighboring island of Socorro is a *Thryomanes*, judged by its structural characters. This fact, taken in connection with the absence of house wrens from the Galápagos and other islands, such as Cocos and the Pearl Islands, affords further evidence of the comparatively modern origin of the group and indicates their fortuitous arrival on the islands where they occur. The case of *Thryomanes insularis* is of corollary interest. If one forgets for the moment the minute structural differences which distinguish it from *Troglodytes*, it is obviously a house wren, differing from *tanneri* only in smaller size and somewhat paler coloration below, while it could scarcely be distinguished, even subspecifically, from certain races of *musculus* such as *striatulus* and *inquietus*. One cannot help wondering whether in this, as in many other cases, the artificial classification of the scientist does not obscure either the origin of a given form or biological relationships of great interest. In the New World wrens of the genus *Troglodytes* and related genera, study of the ever increasing material combined with field experience shows that, no matter how carefully defined the genus, one or more species assigned to it strongly suggest another group in one or more respects. Differences of structure or of proportions, ordinarily regarded as generic characters, in these wrens often appear to be of specific or only subspecific value, and are accompanied by a marked absence of color characters. We are inclined to believe that these two island wrens are biologically more closely related to each other and to the *musculus-aëdon* group than the latter is to the Lesser Antillean mem-

bers of the genus *Troglodytes*, or the *ochraceus-solstitialis* group of the same genus. A classification which refers them to two different genera, which even as now defined are far from homogeneous, is surely unfortunate in obscuring relationships which may be just as important as the discoverable differences.

The present paper is based chiefly upon our own collections, but for substantial reinforcements we are greatly indebted to several other institutions. The U. S. National Museum, the Museum of Comparative Zoölogy, and the Field Museum have loaned all their types of house wrens and such other specimens as we desired to examine. The Bureau of Biological Survey forwarded all specimens in their collections from southern South America. Dr. C. E. Hellmayr very kindly sent us the type of *Troglodytes musculus bonariæ* from Munich. Both he and Dr. Alexander Wetmore of Washington have made suggestions of interest and value.

All measurements are in millimeters, and color terms are from Ridgway's 'Color Standards and Nomenclature.'

***Troglodytes aëdon aëdon* Vieillot**

***Troglodytes aëdon parkmanii* Audubon**

We have nothing to add to the published information on the North American house wren and its western subspecies, but fully indorse the conclusion that *aztecus* is untenable, and all specimens so labelled seen by us should be referred to *parkmanii*. The range of individual variation is so great in both races that casual records of the western house wren on the Atlantic Coast scarcely seem of any value. While we have examined no such specimen, extreme examples of eastern house wrens are quite indistinguishable from average examples of *parkmanii*. It is greatly to be hoped that the southern breeding limits of the house wren in Mexico will be definitely determined.

***Troglodytes musculus peninsularis* Nelson**

Troglodytes peninsularis NELSON, 1901, Proc. Biol. Soc. Wash., XIV, p. 174, September 25 (Progreso, Yucatan; coll. U. S. Nat. Mus.); RIDGWAY, 1904, 'Birds of North and Middle America,' III, p. 574.

SPECIMENS EXAMINED.—MEXICO: Yucatan, Progreso, 4 ♂ (including type); Tamaulipas, Rio Pilon, 1 ♂; Manuel, 1 ♂.

RANGE.—Tropical Coastal Zone of Mexico from southern Tamaulipas to Yucatan.

SUBSPECIFIC CHARACTERS.—Differing markedly from *T. musculus intermedius*, its nearest geographical relative, in being much paler below, the center of the under-

parts being almost pure white; the flanks and sides not so richly or deeply colored; tail averaging much longer. With the small series available, indistinguishable in color from certain variations of both *T. musculus striatulus* and *albicans*, but wing and culmen shorter than in the former, and tail longer than in the latter.

The systematic treatment of this wren is a matter of considerable interest. With a far better understanding of the variation in *musculus* than was available twenty years ago, when it was described, it cannot be regarded as a distinct species, as it possesses no character which one or more races of *musculus* does not have. The fact, therefore, that it differs very markedly from its nearest geographical relative, and that direct intergradation remains to be proven, cannot be used as an argument for its specific distinctness. No one regards the very different Newfoundland hairy woodpecker, for instance, as specifically distinct from typical *villosus* of the northeast, with which it does not intergrade, even though other subspecies in other parts of the continent completely connect the obvious differences between them.

Of equal interest is the fact that *peninsularis* partly closes the gap between *musculus intermedius* and *aëdon*. The only specific differences between the two groups are the proportionately longer tail of *aëdon*; the grayer, less ochraceous brown of the flanks and sides; and the heavier barring on the flanks. The Yucatan wren is exactly intermediate in the proportions of the tail and wing, but otherwise is nearest to the *musculus* type. Its color characters are also partly intermediate between *musculus intermedius* and *aëdon*. As we are able to extend its range northward to southern Tamaulipas, it is apparent that the remaining gap between *musculus* and *aëdon* is a purely zonal one and that *aëdon* is the Temperate Zone representative northwards of *musculus* of the Tropical Zone. The absence of any wren of the *aëdon* type as a breeding bird in temperate Mexico is due either to lack of field work at the proper season, or perhaps to unfavorable competition there with a related species, *T. brunneicollis*.

Troglodytes musculus intermedius Cabanis

Troglodytes intermedius CABANIS, 1860, Journ. f. Orn., 1860, p. 407 (San José, Costa Rica; coll. Berlin Mus.).

Troglodytes musculus intermedius OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 205 (crit.); RIDGWAY, 1904, 'Birds of North and Middle America,' III, p. 576.

Troglodytes hypaëdon SCLATER, 1861, Proc. Zoöl. Soc. Lond., p. 128 (S. Mexico and Guatemala).

Troglodytes musculus hypaëdon OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 204 (crit.); RIDGWAY, 1904, 'Birds of North and Middle America,' III, p. 578.

Troglodytes irrequies BANGS, 1908, Proc. Biol. Soc. Wash., XXI, p. 45, February 29 (Sittee River, Brit. Honduras).

SPECIMENS EXAMINED.—“Mexico” (Sallé), 1 ♂. YUCATAN: Mérida, 1 ♂; “Yucatan,” 5 ? GUATEMALA: Quetzaltenango (8500 ft.), 3 ♂; Lake Amatitlan (4000 ft.), 3 ♂; “Guatemala,” 1 ? BRIT. HONDURAS: Sittee River, 2 ♂, 1 ♀. NICARAGUA: Los Sabalos, 2 ♂. COSTA RICA: San José, 1 ♂, 1 ♀; Barranca, 1 ?; Santa Maria de Dota, 1 ♂, 1 ♀; Bonilla (2000 ft.), 1 ♀; Aquinares (3800–4500 ft.), 3 ♂; Vol. Irazu (8000 and 10,500 ft.) 1 ♂, 1 ♀; Vol. Turrialba (9000 ft.), 1 ♀.

RANGE.—Southern Mexico (Oaxaca, Yucatan, Chiapas); Guatemala; eastern Nicaragua (Rio Coco, Rio Escondido, Los Sabalos), and Costa Rica (except extreme southwest portion).

SUBSPECIFIC CHARACTERS.—Sufficient will be said under *inquietus* to characterize this well-marked race, making repetition unnecessary.

We are unable to recognize *hypoedon* from southern Mexico and Guatemala. It has commonly been considered identical with *intermedius*, but was revived by Oberholser. Ridgway recognizes this race in the text, but has a footnote to the effect that “difference in coloration between specimens from southern Mexico and those from Costa Rica is exceedingly slight and may prove inconstant.” Dr. J. Dwight has just received fresh series collected by Austin Paul Smith in Guatemala and Costa Rica in 1919 and 1920, which are indistinguishable, when due allowance for seasonal differences is made. There are no differences in size. There seems, therefore, no ground for the recognition of two races. However, birds from the mountains of north central Nicaragua and certain volcanoes of the Pacific slope of that country prove to differ constantly from *intermedius* and are described below.

We have also examined the type of *Troglodytes irrequies* Bangs and two other specimens from British Honduras. These prove to be indistinguishable from *T. musculus intermedius*. The differences in color and size, while distinct from *T. m. peninsularis* with which it was compared, are now known to fall well within the known range of variation of the present subspecies, facts with which Mr. Bangs concurs.

***Troglodytes musculus oreopolus*, new subspecies**

SUBSPECIFIC CHARACTERS.—Most closely related to *T. m. intermedius*, but upperparts deeper and more reddish brown, underparts deeper cinnamon-buff, especially on the flanks.

TYPE.—No. 102,943, Amer. Mus. Nat. Hist.; ♀ ad.; Ocotal, Nicaragua (alt. about 4000 ft.); May 7, 1908; Wm. B. Richardson.

SPECIMENS EXAMINED.—NICARAGUA: Ocotal, 1 ♀ (type); San Rafael del Norte (4000 ft.), 3 ♂; Arenal District, 10 miles northwest of Matagalpa (4100 ft.), 1 ♂; Matagalpa (2200 ft.), 4 ♂, 1 ♀, 1 ?; Volcan Viejo (5000 ft.), 2 ♂, 1 ♀, 2 ?; Volcan Mombacho, (2400 ft.), 1 ♂; Chontales (about 1000 ft.), 1 ♂ (approaching *intermedius*).

RANGE.—Mountains of north central Nicaragua, chiefly in the Pine Forests Region, also the town of Matagalpa (2000 ft.); summit of Volcan Viejo above Chi-

nandega (5000 ft.) and summit of Volcan Mombacho above Granada (2400 ft.) on the Pacific slope. A male taken at Chontales (alt. about 1000 ft.) in south central Nicaragua on the boundary line between the Pacific and Caribbean slopes shows a marked approach to *intermedius*.

The distribution and variations of the house wren in Nicaragua in relation to adjacent territory create a problem of exceptional interest. Briefly, the known facts are as follows. In Costa Rica *intermedius*, according to Carriker, is "a common bird throughout the highlands, wherever cultivated lands are found, and extends down into the edge of the lowlands of both the Atlantic and Pacific in small numbers." It is rare below 2000 ft., and extends up to 10,500 ft., without exhibiting any variation. In eastern Nicaragua it is only known from clearings in the forest north to the Honduras boundary. From here to Guatemala there is an apparent gap in the range, which will unquestionably be filled by exploration. In Guatemala the same condition of affairs exists as in Costa Rica. Salvin, writing from extensive field experience, states in the 'Biologia' that it is found throughout the country from sea-level to 8000 feet, affecting the haunts of man and being particularly partial to tile roofs in towns.

It was quite surprising to us, therefore, to find that the house wren was absent from the whole of Nicaragua with the exceptions noted above. We had supposed that its absence from Richardson's collections was due, as in so many other cases, to its being such a common bird. With the single exception of Matagalpa, *oreopolus* is found in localities which could scarcely be farther removed from the haunts of man, and the denseness of the vegetation and the humidity of its haunts might well account for its richer coloring. Finally, we know of no record for the house wren in Salvador, western or central Honduras, though the lack of exploration makes this fact of little significance.

Nicaragua has long been known as a "break" in the ranges of many species or genera which occur both north and south of its boundaries, due without reasonable doubt to the fact that much of it has been submerged, exterminating the original avifauna or driving it to the north and south, the resulting gap never having been filled by subsequent expansion. This subsidence may have exterminated the original house wrens except for colonies on isolated mountain summits on the Pacific side and the northern highlands, which were not affected. The presence of *intermedius* in clearings of the Atlantic forest is a case of expansion from Costa Rica, just as its comparative scarcity at low altitudes in that country is also evidence of expansion from an ancestral highland home.

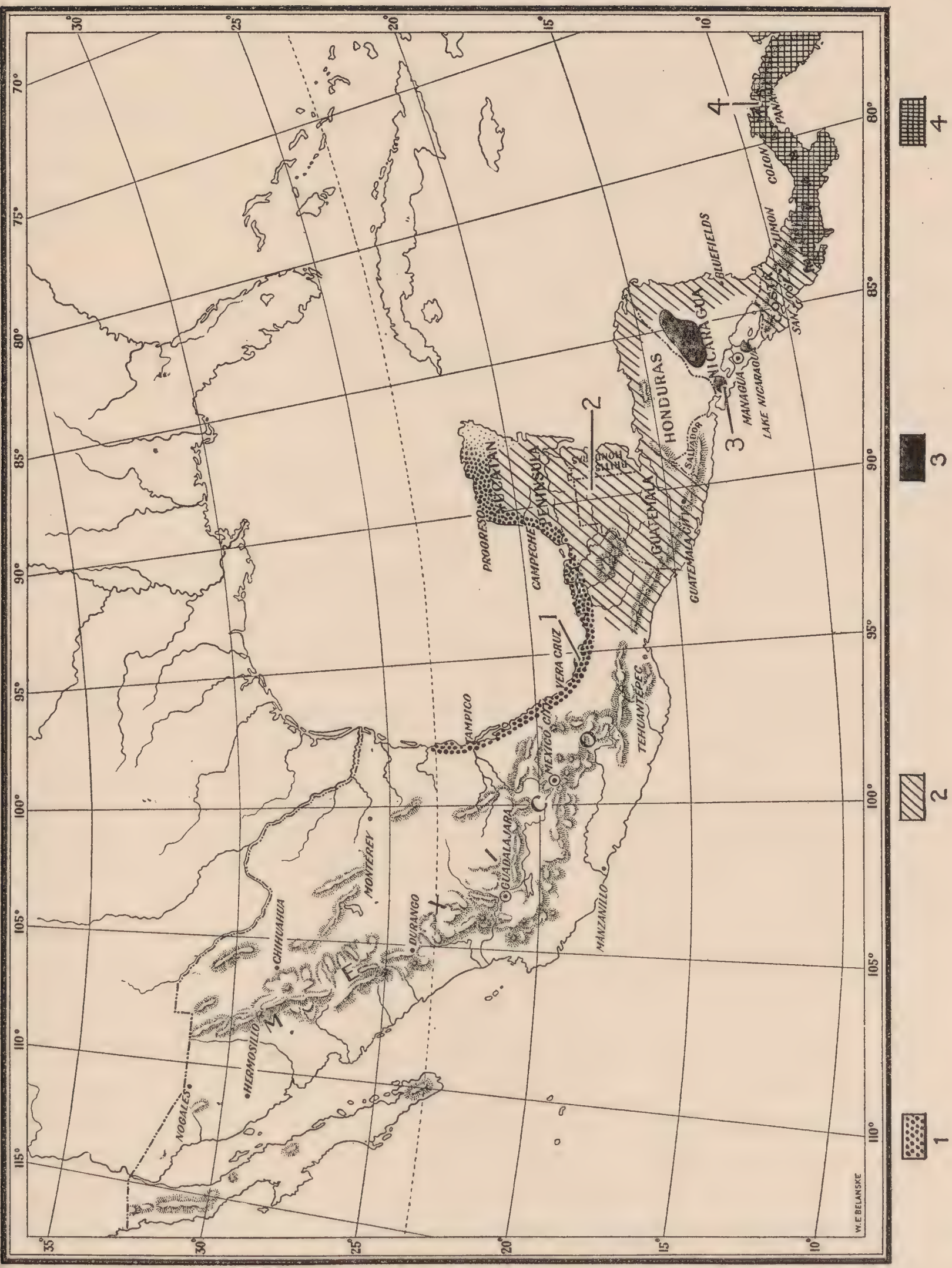


Fig. 1. 1, *Trogodytes musculus peninsularis*; 2, *T. m. intermedius*; 3, *T. m. oreopolus*; 4, *T. m. inquietus*.

The factor, therefore, in the evolution of *oreopolus* may well have been isolation due to continental submergence. Certainly, its distribution cannot be reconciled with life zones or climatic conditions, and it is significant that its probable ancestor, *intermedius*, is not the least affected by such factors, which are all-important with so many other birds.

Troglodytes musculus inquietus Baird

Troglodytes inquietus BAIRD, 1864, 'Review Amer. Birds,' p. 143 (Panama R.R., coll. Amer. Mus. Nat. Hist., "ex Lawrence, MSS.").

Troglodytes musculus inquietus OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 205 (crit.); RIDGWAY, 1904, 'Birds of North and Middle America,' III, p. 575.

SPECIMENS EXAMINED.—PANAMA: Boquete, Chiriqui, 3 ♂, 1 ♀; Canal Zone, 2 ♂ (inc. type), 2 ♀, 1 ?; Chepigana, Darien, 1 ♀; Capeti, Darien, 1 ♂; Rio Tuyra, Darien, 2 ♂, 1 ♀; Cupe River, Darien, 1 ♂.

RANGE.—From extreme southwestern Costa Rica (Boruca) to Eastern Panama.

SUBSPECIFIC CHARACTERS.—Most closely resembling *T. musculus striatulus* but very slightly browner, less grayish-brown above, distinctly more buffy brownish below, and averaging distinctly smaller. From *T. m. intermedius* it differs in being grayer above, less buffy brown below, and is decidedly larger. Worn specimens closely resemble fresh specimens of *albicans* in color but average larger with longer tails.

The Panama house wren has had a somewhat chequered career, systematically. All the Central American forms were first made races of *musculus* by Oberholser, a treatment of their relationships with which we fully agree. Nevertheless, Ridgway in a footnote (*loc. cit.*, p. 571) suggests that a better arrangement would be to consider *inquietus* a race of *T. striatulus*, and *T. intermedius* as specifically distinct, as he had found no intermediates.

While we also have seen no intermediates, *inquietus* is obviously an intermediate between *striatulus* and *intermedius*, and field experience strongly emphasizes the fact that in habits, characteristics, and song, all three are unmistakably house wrens, and are thoroughly representative in their respective areas. Finally, *T. ochraceus* is an excellent illustration of what are really trenchant specific differences in the genus, and its two races occur with both *intermedius* and *inquietus*. There seems no good reason, therefore, for regarding these two latter forms as species on differences which are quantitatively less marked than in many South American races of *musculus*.

Troglodytes musculus atopus Oberholser

Troglodytes musculus atopus OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 207 (Cacagualito, Santa Marta, Colombia).

SPECIMENS EXAMINED.—COLOMBIA: Santa Marta region, Cacagualito, type, 1 ♂, 1 ♀, 1 ?; Bonda, 1 ♂, 1 ♀; Don Amo, 1 ?; Cienaga, 1 ?; Minca, 1 ♀.

RANGE.—Confined to the Tropical Zone of the Santa Marta region of Colombia.

SUBSPECIFIC CHARACTERS.—Differing markedly from any other Colombian race in the deeper ochraceous tone of the underparts. Closest to *intermedius* of Central America, but averaging slightly larger, the bill noticeably longer, and the color of the flanks not so noticeably deeper than the rest of the underparts. The statement that this race is smaller than *clarus* is not supported by the measurements of our large series of the latter race.

Troglodytes musculus striatulus (Lafresnaye)

T[hriothorus] striatulus LAFRESNAYE, Rev. Zool., 1845, p. 338 ("Bogotá," Colombia; by subseq. desig., Honda).

Troglodytes musculus striatulus OBERHOLSER (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 205; CHAPMAN, 1917, Bull. Amer. Mus. Nat. Hist., XXXVI, p. 518 (crit.).

SPECIMENS EXAMINED.—COLOMBIA: Alto Bonito, Antioquia, 1 ♂; Dabeiba, Antioquia, 3 ♂; Bagado, Chocó, 1 ♂; Puerto Valdivia, Antioquia, 1 ♀; La Frijolera, Antioquia, 1 ♂; Caldas, Cauca, 2 ♂, 1 ♀, 1 ?; Las Lomitas, Cauca, 2 ♂, 1 ♀, 1 ?; San Antonio, Cauca, 3 ♂, 2 ?; Cali, Cauca, 1 ♂, 2 ♀, 2 ?, Rio Frio, Cauca, 1 ♂; Salento, Cauca, 1 ♀; Santa Elena, Antioquia, 1 ♀; Rio Toché, Tolima, 2 ♂, 1 ♀; La Sierra, Cauca, 1 ?; Chicoral, Tolima, 1 ♂; Honda, Tolima, 1 ♂, 1 ?; Anolaima, 2 ?; Choachi, Bogota, 1 ?; Miraflores, Cauca, 4 ♂; "Cauca," 1 ♂, 1 ?; "Bogota," 3 ?

RANGE.—Tropical and Subtropical zones of Colombia from the western slope of the Eastern Andes westward, exclusive of Santa Marta and extreme southwestern Colombia. One of the Anolaima specimens is an intergrade with *T. m. columbæ*.

SUBSPECIFIC CHARACTERS.—This race is the palest of all the races of *musculus*, the most grayish brown above and the whitest below. In its large size it is exceeded only by *puna* of the high Peruvian Andes. Specimens from extreme southwestern Colombia, formerly referred to this race, prove to be *albicans*. The faint indications of barring on the back, which so often appear as an individual variation in various races of the house wren, in this race are more constant than in any other, and are a sub-specific character.

Troglodytes musculus columbæ Stone

Troglodytes columbæ STONE, 1899, Proc. Acad. N. S., Phila., p. 308 (vicinity Bogotá).

Troglodytes musculus striatulus OBERHOLSER (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 205.

Troglodytes musculus columbæ CHAPMAN, 1917, Bull. Amer. Mus. Nat. Hist., XXXVI, p. 520 (crit.).

SPECIMENS EXAMINED.—COLOMBIA: El Roble, 1 ♀; El Piñon, 1 ♂, 1 ♀; Chi-paque, 3 ♂, 2 ♀; Fomeque, 1; Quetame, 1 ?; La Holanda, 2 ♂; Tocaimito, above Bogotá, 1 ♂; Choachi, 2; Puento Andalucia, 1 ♀; Bogota Region, 1.

RANGE.—Temperate Zone of both slopes of the Eastern Andes of Colombia.

SUBSPECIFIC CHARACTERS.—Distinguished from all other races of *musculus* by the uniform vinaceous-buff of the underparts from bill to vent, with no white areas.

Upperparts darker than in *striatulus*, its closest relative, but distinctly gray-brown. Every one of our specimens is finely barred above, perhaps here a diagnostic character, rather than individual variation. Size large, exceeded only by *striatulus* and *puna*. Compared with the latter, the only other Temperate Zone Andean house wren, it is much less richly colored. A specimen from Quetame approaches *T. m. albicans*.

***Troglodytes musculus albicans* Berlepsch and Taczanowski**

Troglodytes furvus albicans BERLEPSCH AND TACZANOWSKI, 1883, Proc. Zool. Soc. Lond., p. 540 (Guayaquil, Ecuador).

Troglodytes musculus albicans OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 207.

Troglodytes musculus clarus BERLEPSCH AND HARTERT, 1902, Novit. Zool., IX, p. 8 (Bartica Grove, Brit. Guiana); OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 206 (crit.).

Troglodytes musculus neglectus CHAPMAN, 1917, Bull. Amer. Mus. Nat. Hist., XXXVI, p. 520 (Buena Vista, alt. 4500 ft., Eastern Andes, Colombia).

Troglodytes musculus paramaribensis BANGS AND PENARD, 1918, Bull. Mus. Comp. Zool., LXII, No. 2, p. 81 (vicinity of Paramaribo, Surinam).

Troglodytes musculus chapmani STONE, 1918, Auk, p. 244.

SPECIMENS EXAMINED.—COLOMBIA: Barbacoas, 2 ♂; Tumaco, 3 ♂, 2 ♀; Buena Vista, eastern base of Eastern Andes, alt. 4500 ft., 5 ♂, 1 ♀ (including type of *neglectus* Chapman = *chapmani* Stone). ECUADOR: Esmeraldas, 3 ♂; Rio de Oro, Manaví, 4 ♂, 2 ♀; Zaruma, Prov. del Oro (alt. 6000 ft.), 1 ♂ ?; Isla de Puna, 1 ♂, 3 ♀; Isla La Plata, 1 ♂, 4 ♀, 1 ?; Daule, Prov. of Guayas, 1 ♂; Duran, Prov. of Guayas, 1 ♂, 1 ♀, 1 ?; Rio Pindo, Prov. del Oro (1850 ft.), 1 ♂; Portovelo, Prov. del Oro (2000 ft.), 1 ?; El Chiral, Prov. del Oro (alt. 5350 ft.), 1 ♀; Celica, Prov. de Loja (alt. 6900 ft.), 1 ♀; Alamor, Prov. de Loja (alt. 4550 ft.), 1 ♂; Casanga, Prov. de Loja (alt. 2900 ft.), 1 ♂, 1 ♀, 1 ? PERU: Lamor, Prov. Piura, 1 ♂; Paletillas, Prov. Piura, 2 ?; Samate, Prov. Piura, 2 ♂, 1 ♀; Bellavista, 1 ♀; Huancabamba, 3 ♂; Palambla (3900–6500 ft.), 6 ♂, 2 ♀, 1 ? VENEZUELA: El Cuji, Estado Lara, 2 ♂; Barquisimeto, Estado Lara, 1 ♂; Cotiza, Caracas, 1 ♂, 2 ♀; Las Trincheras, Estado Carabobo, 4 ♂, 1 ♀; San Antonio, Bermudez, 1 ♂, 1 ♀; Cumanacoa, Bermudez, 2 ♂, 1 ♀; Cristobal Colon, Paria Peninsula, 1 ♂, 1 ♀; Maripa, 3 ♂; La Union, Caura, 3 ♂; Suapure, 2 ♂; "Venezuela," 2 ? TRINIDAD: Princetown, 3 ♂, 2 ♀. BRITISH GUIANA: Wismar, Demerara River, 1 ♂; Essequibo River, 1 ♀. Surinam: vicinity of Paramaribo (including type of *paramaribensis* Bangs and Penard), 1 ♂, 4 juv. BRAZIL: Utinga, near Pará, 1 ♂; Monte Alegre, 1 ♂; Faro, Rio Jamundá, 1 ♂; Porto Velho, Rio Madeira, 2 ♂, 2 ♀; Calama, Rio Madeira, 1 ♀ ?; Solimoes, Amazonas, 1 ♀; Tres Buritys, Matto Grosso, 1 ♀.

RANGE.—From extreme southwestern Colombia (Tumaco, Barbacoas) through the Tropical and Subtropical zones of western Ecuador to northern Peru; also the whole of northeastern South America from Pará and the Rio Madeira region of Brazil north to the coast of Venezuela, the Guianas, and Trinidad, and east to the base of the eastern Andes of Colombia. No house wren is recorded from the Temperate Zone in Ecuador.

SUBSPECIFIC CHARACTERS.—This race is most closely related to typical *musculus*, but differs in being much lighter in tone below. While the flanks in fresh specimens

are as richly colored as in *musculus*, the median portion of the lower surface is white or whitish, giving a strongly contrasted color effect. In size it is small like *musculus*, but the tail is shorter in proportion than in any other race.

No other house wren illustrates better the remarkable extent of individual variation in this group. Wear will turn a rich brown back to grayish-brown, and eliminate almost all the rich color on the flanks. Large series are consequently essential in determining what characters are individual and what are subspecific. With fifty-one specimens of *albicans* and fifty-seven of "*clarus*" before us, representing every part of the known range of these two races, it has been impossible to discover even one constant character by which they can be separated. There is no difference whatever in color or size. Oberholser distinguished "*clarus*" on the basis of only its plain under tail-coverts. We, however, find twenty-seven specimens of "*clarus*" from all parts of its range, with distinctly barred under tail-coverts, and similarly we have seventeen specimens of *albicans* with immaculate under tail-coverts. Barring of the back is a purely individual variation in this race, but it is interesting to note that in specimens from eastern and southwestern Colombia, where its range approaches most closely that of *striatulus*, this barring increases in constancy.

Failure to appreciate this extraordinary amount of individual variation has led to the description of two other races within the range of *albicans*. *T. m. paramaribensis* from Surinam, based on an adult male and four juvenal specimens, is not, in our opinion, separable. These specimens Mr. Bangs had kindly forwarded for examination. The type can be matched in color of both upper and underparts by specimens from Trinidad and the whole of northern Venezuela; it is larger than the average "*clarus*," and has the upperparts more distinctly barred with black, but the latter character is individual rather than racial, and is well known to occur in other races of house wrens. Similarly the characters on which *neglectus* Chapman (= *chapmani* Stone) was described prove to be individual and not racial.

In view of the presence of the house wren in the Temperate Zone of the eastern Andes of Colombia and of Peru, it is surprising to find that no form of this bird has been recorded from this zone in Ecuador, nor have our expeditions found it there. All the more surprising is it, therefore, to discover that *albicans* evidently crosses the Andes west of Huancabamba, in northern Peru. The pass in the range on the route between Huancabamba and Payta here attains an altitude of only about 7500 feet, well within the altitudinal limits of the Subtropical Zone. House

wrens from Huancabamba (alt. 6500 ft.), and Bellavista, Peru, THE LATTER LOCALITY ON THE MARAÑON, have already been referred to *albicans* by Bangs and Noble (Auk, 1918, p. 457) and we have since received specimens from this region. The Bellavista specimen was thought by these authors to approach *tecellatus*, but it seems evident that this opinion was based on material wrongly identified as *tecellatus*, for the Bellavista bird does not resemble that form, and, except for its longer tail, can be matched by west Ecuador examples. Whether or not it may be considered desirable to recognize both *clarus* and *albicans*, it seems clear that we have in these north Peruvian specimens evidence that the house wren has here reached the Pacific Coast.

Troglodytes musculus tobagensis Lawrence

Troglodytes tobagensis LAWRENCE, 1888, Auk, V, p. 404 (Tobago, West Indies; type in Amer. Mus. Nat. Hist.).

Troglodytes musculus tobagensis OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 206.

SPECIMENS EXAMINED.—TOBAGO: 2 ♂ (including type).

RANGE.—Island of Tobago.

SUBSPECIFIC CHARACTERS.—Exactly similar to *albicans* in color, but very much larger in size, equalling *striatulus*.

This race is apparently worthy of recognition, as specimens from Trinidad and the Paria Peninsula of Venezuela only slightly approach Tobago birds in dimensions.

Troglodytes musculus musculus Naumann

Troglodytes musculus NAUMANN, 1823, 'Vögel Deutschl.,' III, p. 724, table (Lichtenstein manuscript). Bahia.

Troglodytes musculus musculus OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 202.

Thryothorus wiedi BERLEPSCH, 1873, Journ. für Orn., XXI, p. 221. New name for *T. platensis* Wied (*nec* Latham). Type locality by subseq. desig. Rio de Janeiro; see Hellmayr, 1919, Verhandl. Orn. Gesell. Bayern, XIV, Heft 1, p. 129, footnote.

Troglodytes musculus wiedi OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 202.

Troglodytes guarixa PUCHERAN (*nec* Des Murs, 1847), 1855, Arch. Mus. Paris, VII, p. 338; see Hellmayr, 1908, Novit. Zool., XV, p. 18.

Troglodytes musculus beckeri CORY, 1916, Field Mus. Nat. Hist. Publ., I, p. 244 (Serra Baturité, Ceará, Brazil).

SPECIMENS EXAMINED.—BRAZIL: Macaco Secco, 1 ♀; Serra Baturité, Ceará, 1 ♂ (type of *T. m. beckeri*); Bahia, 4 ♂, 2 ?; near Rio de Janeiro, 2 ? (types of *T. platensis* Wied); Rio de Janeiro, 2 ?; La Raiz, Organ Mts., 1 ♂, 1 ♀; Therezopolis, Organ Mts., 1 ♂, 1 ♀; Piquette (near São Paulo), 1 ?; Victoria, São Paulo, 1 ?; Chapada, Matto Grosso, 8 ♂, 1 ♀, 1 ?; Urucum, near Corumbá, Matto Grosso, 3

♂, 1 ♀, 1 ?; Tapirapoan, Matto Grosso, 1 ♂. PARAGUAY: Trinidad 1 ♀; Puerto Pinasco, 1 ♂, 1 ♀; Fort Wheeler, Paraguayan Chaco, 1 ♂, 1 ♀. ARGENTINA: Iguazú, Misiones, 1 ♂.

RANGE.—Brazil, from the Province of Ceará to São Paulo, west to Goyaz, Minas Geraes and Matto Grosso, and south to Paraguay. It does not occur typically in Argentina. In Misiones it intergrades with *bonariæ*.

SUBSPECIFIC CHARACTERS.—This race is the deepest and most richly colored of all with the exception of *puna*, which is one of the smallest. It is very variable in color, and many specimens are comparatively pale in tone below, a fact which has led to the description of other races from the range we ascribe to *musculus*.

For many years *musculus* was restricted to Bahia, all other specimens from its range being called *guarixa*. We concur in Hellmayr's recently expressed views that this latter race is untenable. Specimens from Bahia, the type locality, are as different from each other as "*guarixa*" is from *musculus*, while Paraguayan specimens are inseparable from others from Bahia. *T. m. beckeri*, described from one specimen, and with only one specimen of *musculus* for comparison, is but slightly paler than the most richly colored skins from Bahia and is typical *musculus* in every respect. According to Hellmayr, a specimen from Goyaz is scarcely distinguishable from *clarus* (= *albicans*). Birds from extreme northern Matto Grosso are also plainly referable to the latter race, but a series from Chapada, while noticeably paler below than our specimens of *musculus*, obviously belongs here, though approaching *clarus*. Their characters, in any event, are not sufficiently well defined for subspecific characterization.

It should be noted that in *musculus* the barring of the back and under tail-coverts is a matter of individual variation.

***Troglodytes musculus rex* Berlepsch and Leverkühn**

Troglodytes furvus rex BERLEPSCH AND LEVERKÜHN, 1890, Ornith., p. 6 (Samaipata, Bolivia).

Troglodytes musculus rex OBERHOLSER (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 202.

SPECIMENS EXAMINED.—BOLIVIA: Dept. of Santa Cruz, Vermejo (3500 ft.), 3 ♂; Chilon (5600 ft.), 1 ♂; California (6600 ft.), 1 ♂; Dept. of Sucre, Pulque (9400 ft.), 3 ♂, 2 ♀; Rio Cachimayo (8700 ft.), 4 ♂, 2 ♀; Rio Pilcomayo (8000 ft.), 2 ♂; Dept. of Cochabamba, Parotani (8800 ft.), 6 ♂, 1 ♀, 1 ?; Vinto (8600 ft.), 1 ♂, 3 ♀; Tujma (8200 ft.), 1 ♂, 1 ♀. ARGENTINA: Prov. de Jujuy, Tilcara (8000 ft.), 1 ♂; Volcan (7000 ft.), 1 ♂; Prov. de Tucuman, Tafi del Valle (7000 ft.), 3 ♂, 4 ♀; Tafi Trail (2000 ft.), 1 ♂, 2 ♀; above San Pablo (4000 ft.), 2 ♂; Sarmiento (1700 ft.), 4 ♂, 1 ♀; Prov. de Salta, Rosario de Lerma (4800 ft.), 2 ♂; Embarcacion (1700 ft.), 1 ♂; Lavalle, Santiago del Estero (1800 ft.), 1 ♂; Suncho Corral, Santiago del Estero (1800 ft.), 3 ♂; Gob. de Chaco, General Pinedo, 1 ♀; Avia Terai, 3 ♂, 4 ♀; Resistencia, 1 ♀; Las Palmas, 2 ♂, 2 ♀; Kilometro 182, Formosa, 1 ?

RANGE.—Eastern and central Bolivia to northwestern Argentina.

SUBSPECIFIC CHARACTERS.—Distinguishable from any other race of *musculus* by having the entire underparts strongly tinged or suffused with isabelline, giving them a pinkish rather than an ochraceous tone.

A very few specimens have faint bars on the back, while the presence or absence of barring or spotting on the under tail-coverts is purely a matter of individual variation. In size this race averages distinctly larger than typical *musculus*, and, as might be expected, birds from the higher altitudes average larger than those from lower levels, but this difference is not sufficiently great for subspecific separation.

Few house wrens have had a more chequered career than *rex*, and its range has not been heretofore known. Count Berlepsch, in describing *puna*, overlooked his previous description of *rex*, and, when he remembered it, supposed he had redescribed it. Thus the range of *rex* was erroneously extended to eastern and central Peru by recent authors. Specimens from Vermejo and Chillon, Bolivia, are essentially topotypical and they are certainly not separable from our large series from the localities in Bolivia and northwestern Argentina listed above. All are distinguished by the strong isabelline color of the underparts, a character to which attention was called in the original description.

To the east this form intergrades with *musculus*, specimens from the Argentine Chaco showing a decided approach to that race. To the south it merges into *chilensis*, but we have no evidence of its intergradation with *puna*.

Troglodytes musculus carabayæ, new subspecies

Troglodytes musculus audax CHAPMAN (not of Tschudi), 1921, Bull. U. S. Nat. Mus., No. 117, p. 103 (Santa Ana specimens).

SUBSPECIFIC CHARACTERS.—Very closely resembling *T. m. audax*, differing only in having the back finely but distinctly barred with blackish.

TYPE.—No. 146, 338, Amer. Mus. Nat. Hist.; ♀ ad.; Santo Domingo, S. E. Peru, alt. 6000 ft.; September 4, 1916; H. Watkins.

RANGE.—So far as known the Tropical Zone of central to southeastern Peru.

SPECIMENS EXAMINED.—PERU: Utcuyacu, 1 ♂; Tulumayo, 3 ♂, 1 ♀; La Merced, 3 ♂, 2 ♀; Santa Ana, 4 ♂, 1 ♀, 1 ?; Rio Inambari, 1 ♂, 1 ♀; Santo Domingo, 1 ♂, 1 ♀.

This race so nearly resembles *audax* that the senior author has referred Santa Ana specimens of it to that race, and it is possible that still further material will show it to be based on individual rather than racial variation, just as we believe is the case with *clarus*. Considering, however, the different climatic conditions prevailing in the ranges of these two forms, and the fact that these regions are separated by a

mountain range reaching to the Puna Zone, it seems advisable to maintain these two races as distinct for the present. An old and very dirty skin from Mapiri, northeastern Bolivia, probably belongs here.

Troglodytes musculus puna Berlepsch and Stolzmann

Troglodytes musculus puna BERLEPSCH AND STOLZMANN, 1896, Proc. Zool. Soc., p. 329 (Ingapirca); CHAPMAN, 1921, Bull. U. S. Nat. Mus., No. 117, p. 102.

Troglodytes musculus tecellatus OBERHOLSER (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 203.

SPECIMENS EXAMINED.—PERU: Dept. of Junin, Chipa (12,400–14,000 ft.), 6 ♂, 4 ♀; Rumicruz (8700 ft.), 3 ♂, 2 ♀; Tirapata, Titicaca Basin (12,700 ft.), 1 ♂, 1 ♀; Puno, Lake Titicaca (12,500 ft.) 1 ♂, 1 ♀; Ttica-Ttica (11,500 ft.), 2 ♂, 1 ♀, 1 ?; Cuzco (11,000 ft.), 2 ♀, 2 ♀; Huaracundo Cañon (10,000 ft.), 1 ♂, 1 ?; Chospiyoc (10,000 ft.) 1 ♀ 1 ?; Ollantaytambo (9700 ft.), 1 ♂, 2 ♀; La Raya, 3 ♀; Pisac, 2 ♂; Calca, 1 ♀, 1 ?; Oroya, Rio Mantaro, 1 ♂; Limbani (10,000 ft.), 1 ♀; Acobamba, 1 ♂; Occabamba Pass (13,000 ft.), 1 ♂. BOLIVIA: Guaqui (12,000 ft.), 2 ♀.

RANGE.—Arid Temperate and Puna Zones of central and southern Peru and extreme northern Bolivia.

SUBSPECIFIC CHARACTERS.—This is the best-marked race of *musculus*. It is as richly and deeply colored below as typical *musculus* and is the largest of all the races.

It has no close affinities with *rex* or *tecellatus*, with both of which it has been synonymized. On the eastern slope of the Andes, this race intergrades with *carabayæ* of the Tropical Zone, specimens from Machu Picchu and Torontoy being almost exactly intermediate. Even specimens from Ollantaytambo show an approach to *carabayæ* in the paler color of the underparts.

Troglodytes musculus audax Tschudi

Troglodytes audax TSCHUDI, 1845–46, 'Fauna Peruana,' p. 185 (coast of Peru; see Berlepsch and Hellmayr, Journ. für Ornith., 1905, p. 6).

Troglodytes musculus enochrus OBERHOLSER, 1904, Proc. U. S. Nat. Mus., XXVII, p. 207 (coast region of Peru, near Lima).

SPECIMENS EXAMINED.—WESTERN PERU: Trujillo, Prov. La Libertad, 2 ♂, 1 ♀; Sayan, Prov. Lima, 2 ♂; Vitarte, Prov. Lima, 10 ♂; Huacho, Prov. Lima, 5 ♂, 1 ♀; Huaral, Prov. Lima, 11 ♂, 6 ♀; Lima, 3 ♀ (including type of *enochrus*); Callao, 1 ♀ ?; Pisco, 4 ♂, 1 ♀; Ica, 1 ♂.

RANGE.—The arid west coast region of Peru, from Trujillo south at least to Ica and Pisco.

SUBSPECIFIC CHARACTERS.—Most closely related to *T. m. albicans*, but the underparts more uniformly ochraceous; lacking any distinct median whitish portion. It is thus almost exactly intermediate in color between *musculus* and *albicans*. It is much smaller and less richly colored than *puna*. Certain specimens from Pisco and Ica show very faint barring on the back. With this exception our large series has uniform upperparts.

Although the ranges of *audax* and *chilensis* are separated by that of *tecellatus* which, in our opinion, is specifically distinct from both, *audax*

is closely related to the Chilean bird. It has the same tawny-ochraceous tail and rump, but its underparts are more deeply colored, and the back in some specimens shows traces of bars, a character practically absent in *chilensis*. The under tail-coverts are never heavily barred and often are unmarked.

***Troglodytes tecellatus* Lafresnaye and d'Orbigny**

Troglodytes tecellata LAFRESNAYE AND D'ORBIGNY, 1837, Mag. de Zool., CL., 2, p. 25 (Tacna, Peru [= Chile]).

Troglodytes musculus tecellatus OBERHOLSER (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 203.

SPECIMENS EXAMINED.—SOUTHWESTERN PERU: Lomas (near Vitor), 4 ♂; Ilo, 2 ♂; Cocachacra, 6 ♂, 1 ♀; Moquegua, 2 ♂, 3 ♀.

RANGE.—River valleys in the coast district of southwestern Peru and northwestern Chile.

SPECIFIC CHARACTERS.—Resembling *Troglodytes musculus audax*, but upperparts grayer brown, broadly and conspicuously barred with black; rump not so strongly rufescent, strongly barred; tail very slightly rufescent, broadly and heavily barred with black, some specimens having more black than rusty-brown; beneath slightly paler; the under tail-coverts heavily barred, and in some specimens even the flanks are barred, a character not found in any race of *musculus* but present in *aëdon*.

In the majority of the South American house wrens barring on the back is a matter of individual variation, *albicans* affording the extreme illustration. In two races, *striatulus* and *carabayæ*, it is sufficiently constant to be an average subspecific character, but in *tecellatus* it is so developed and stable a character that we regard it of specific value in the absence of all proof of intergradation. It is of particular significance to note that the two adjoining races of *musculus*, *audax* on the north and *chilensis* on the south, have as little barring on the back as any form of the group.

Our specimens from Moquegua differ from the rest of the series in being less barred on the upperparts. More material is essential to determine whether this difference is subspecific or individual. In any event, they cannot be regarded as intergrades with any race of *musculus*.¹

¹As this paper is about to go to press, we have received a description (Field Museum Pub. No. 219, p. 74) by Dr. C. E. Hellmayr of a new form of house wren from the Rio Loa, east of Antofagasta, Chile. We have seen no specimens of this form which, under the name *Troglodytes musculus atacamensis*, is described as follows:

"Similar to *Troglodytes musculus chilensis* Lesson, from central Chile, but with decidedly slenderer, also somewhat longer bill, and of much paler coloration; pileum and back pale grayish brown (sometimes with a slight rufescent tinge), instead of dark smoke-brown; rump and upper tail coverts lighter rufous; wings less rufescent, tail paler; under parts paler isabelline with throat and middle of abdomen more whitish, flanks and under tail coverts lighter ochraceous. Similar also to *Troglodytes musculus tecellatus* Lafr. & d'Orb. from province of Tacna, particularly above, but easily distinguished by brighter rufous rump, pale rufescent instead of grayish brown tail, more isabelline, less whitish under parts with deeper ochraceous flanks and crissum, and by lacking all trace of blackish bars on either back or upper tail coverts. Wing (male), 51–54, (female) 50; tail, 43–47; bill, 13½–14½ mm."

While Dr. Hellmayr considers this race to be a "connecting link" between *chilensis* and *tecellatus* it is clear, even without examining specimens, that in its unbarred back and rufescent tail it is far from actually bridging the wide gap between the forms to the north and south of it. The intergradation of *tecellatus* remains therefore to be proved.

Troglodytes musculus chilensis Lesson

Troglodytes chilensis LESSON, 1830, 'Voy. Coq., Zool.,' I, p. 665 (Concepcion, Chile); see Hellmayr, Nov. Zool., 1921, pp. 273-275 (contains a valuable discussion of all the races of southern South America in addition).

Thriothorus rosaceus LESSON, 1840, Rev. Zool., p. 262 (La Plata and Chile); see Hellmayr, 1919, Verh. Orn. Ges. Bay., XIV, No. 1, p. 128, footnote.

Troglodytes musculus hornensis OBERHOLSER (*nec* Lesson) (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 203.

Troglodytes musculus acosmus OBERHOLSER, *idem*, p. 204 (central Chile).

SPECIMENS EXAMINED.—CHILE: Corral, 2 ♂, 1 ♀; Temuco, Cautin, 1 ♂; near Santiago, 2 ♂, 2 ♀, 1 ? (type of *acosmus*); Valparaiso, 1 ♂, 1 ♀; Tofo, 60 miles north of Coquimbo, 2 ♂, 1 ?; "Chile," 1 ♂, 2 ? ARGENTINA: La Plata, Prov. Buenos Aires, 1 ♂; Conchitas, Buenos Aires, 4 ♂, 1 ♀; Angaco Sud. Prov. de San Juan, 1 ♂, 1 ♀; Victorica, Pampa, 1 ♂, 1 ♀; Mendoza, 1 ♂; Tunyán, Prov. de Mendoza, 1 ♂, 1 ♀; Potrerillos, Prov. de Mendoza (alt. 5000 ft.), 2 ♂, 5 ♀.

RANGE.—Chile, from Corral (probably Canal de Chacao) north at least to Tofo, 60 miles north of Coquimbo, altitudinal range unknown; Argentina from the Rio Negro region north at least to Mendoza, and in winter to the La Plata district.

SUBSPECIFIC CHARACTERS.—Resembling *T. m. audax*, the rump, upper tail-coverts and tail ochraceous-tawny, much as in that race; the back averaging darker; underparts decidedly paler than in *audax*, the breast washed with pale wood-brown (avellaneous) rather than light pinkish cinnamon; back without trace of bars, the under tail-coverts usually with a few black marks. Similar to *T. m. bonariæ* but upperparts brighter brown; rump, upper tail-coverts and tail ochraceous-tawny rather than cinnamon-brown, bars on under tail-coverts less frequent and when present usually smaller.

So far as Chile is concerned, *T. m. chilensis* appears to be a southern representative of *T. m. audax*, which, from at least Tofo to Ancud (and probably the Chacao Canal) is uniform in size and color. From Ancud, on the island of Chiloé, just south of Chacao Canal, we have fairly typical specimens of *magellanicus*, to be distinguished from *chilensis* chiefly by their smaller bill.

The range of *chilensis* in the Andes is unknown to us, but both Peters and Wetmore secured wholly typical examples in March at Potrerillos, alt. 5000 ft., on the Argentine slope above Mendoza. Chapman secured it in August at Mendoza, whence it ranges entirely across Argentina to the Buenos Aires region WHERE IT IS FOUND ASSOCIATED WITH THE URUGUAYAN FORM. The status of the two forms in this region is discussed beyond.

Specimens from Angaco Sud, Province of San Juan, northeast of Mendoza appear to be intermediate between *chilensis* and *rex*.

Troglodytes musculus bonariæ Hellmayr

Troglodytes musculus bonariæ HELLMAYR, 1919, Anz. Orn. Ges. Bay., No. 1, February, p. 2 (La Plata, Prov. Buenos Aires, Argentina); 1919, Verh. Orn. Gells. Bayern, XIV, I, p. 128.

Troglodytes musculus hornensis OBERHOLSER (*nec* Lesson) (part), 1904, Proc. U. S. Nat. Mus., XXVII, p. 203.

SPECIMENS EXAMINED.—ARGENTINA: Buenos Aires, 2 ♂; Lavalle, Buenos Aires, 4 ♂; Barazetegui, Buenos Aires, 1 ♀. URUGUAY: Montivideo, 1 ♂, 1 ♀; Concepcion del Uruguay, 1 ♂, 1 ♀; Rio Negro, 4 ♂; Lazcano, Rocha, 1 ♂, 1 ♀; San Vincente, Rocha, 1 ♂. BRAZIL: Blumenau, Santa Catharina, 1 (cotype of *T. wiedi* Berlepsch).

RANGE.—From extreme southeastern Brazil through Uruguay to the Province of Buenos Aires, Argentina.

SUBSPECIFIC CHARACTERS.—Similar to *T. m. musculus*, but upperparts much darker and grayer brown; rump and tail less markedly rufescent; underparts much paler and less richly colored. Faint barring on the back is occasional in our specimens, most of which have the under tail-coverts barred. In size it is like *musculus*. The specimen from Santa Catharina is barely separable from *musculus*, indicating the area of intergradation. Similar to *T. m. chilensis* but upperparts, particularly the rump, upper tail-coverts and tail cinnamon-brown rather than ochraceous-tawny, the back usually with at least traces of bars, the under tail-coverts usually barred, the bars larger.

This appears to be the only form of house wren inhabiting Uruguay, whence we have an adequate series. It is also found in the adjoining Argentine province of Entre Rios and on the west shores of La Plata to La Valle at Punta del Morte. We have eight specimens from this part of Argentine which agree closely with the Uruguay series, as follows: Concepcion del Uruguay, June 23, 1880, 1 ♀; Hurlingham, 14 m. west of Buenos Aires, September 10, 1916, 1 ♀; La Plata, May 15, 1904, 1 ♀; La Valle, October 23, 1920, 1 ♂; May 6, 1921, 1 ♂, May 16, 1921, 2 ♂.

From essentially the same region we have eight specimens which are obviously to be referred to *chilensis* rather than to the Uruguayan form, as follows: Concepcion del Uruguay, June 23, 1880, 1 ♂; Conchitas (between Buenos Aires and La Plata), April 1868, 1 ♂, 1 ♀; July, 2 ♂; August, 1 ♂; La Plata, March 1896, 1 ♂; April 1906, 1 ♂.

In no other instance have we found two forms of *musculus* associated. In explanation it may be suggested (1) that the specimens referred to *chilensis* having been taken many years ago have faded; (2) that the differences observed are due to individual variation; (3) that *chilensis* as the more southern form occurs only as a migrant in the region occupied by the Uruguayan bird. To which it may be replied as follows: (1.) The specimens examined give no indication of having faded, and the fact that of two birds taken by Barrows at Concepcion del Uruguay on the same day one represents the Chilean the other the Uruguayan form indicates that there has been no postmortem change in the color of either. (2.) The constancy in color shown by both Chilean and Uruguayan birds precludes the probability of either one exhibiting the wide range of

variation noted in the Buenos Aires region. (3.) It is possible that *chilensis* may occur only as a winter visitant in the Buenos Aires region. Our specimens of it from this area are all taken between March and August 1, and therefore furnish only negative evidence in this connection.

Meanwhile, we have to consider the inevitable question of names on which Hellmayr has already thrown so much light. This author has shown that *rosaceus* Lesson, described from "La Plata and Chile," is based on the Chilean form, though it is by no means unlikely it was described from a La Plata specimen. After restricting the name *rosaceus* to the Chilean bird (for which he subsequently discovered the name *chilensis*) Hellmayr described the Uruguayan form as *bonariæ*, assigning to it the range of the provinces of Buenos Aires, Entre Rios, Corrientes in Argentina, Uruguay, and southeastern Brazil, and taking for his type a specimen from La Plata. This specimen, thanks to Dr. Hellmayr, we have examined. While not wholly typical of the Uruguay race, it is possibly nearer that form than to *chilensis* and hence, in our opinion, the name *bonariæ* should be accepted for the resident form of the La Plata region.

Dr. Alexander Wetmore, however, calls our attention to a record by J. B. Daguerre in 'El Hornero' (II, 1922, p. 270) who states that "*Troglodytes musculus magellanicus*" is in some winters very common at Rosas in the Buenos Aires region from May to September. True *magellanicus* is known to occur near Buenos Aires in winter but, since this species probably does not breed north of the Rio Negro, those wrens from north of that river which migrated to the Buenos Aires region for the winter would doubtless be referred to *chilensis* rather than to *magellanicus*. Hence, under that name Daguerre has doubtless included both forms, when we should have a wholly satisfactory explanation of the occurrence of *chilensis* in the La Plata district.

***Troglodytes musculus magellanicus* Gould**

Troglodytes magellanicus GOULD, 1836, Proc. Zoöl. Soc. London, p. 88 ("in Fretu Magellanico").

Troglodytes musculus hornensis OBERHOLSER (*nec* Lesson), 1904, Proc. U. S. Nat. Mus., XXVII, p. 203.

Troglodytes musculus magellanicus HELLMAYR, 1919, Verh. Orn. Ges. Bay., XIV, No. 1, p. 128, footnote.

SPECIMENS EXAMINED.—CHILE: Ancud, 3 ♂, 1 ?; Punta Arenas, 2 ♂, 1 ♀ ?; Cape Horn, 1 ♂, 1 ♀; False Cape Horn, 3 ♂, 1 ?; Londonderry Island, 1 ♂. ARGENTINA: Terr. Rio Negro, near Maquinchao, 1 ♀; Bariloche, 2 ♂, 1 ♀; Huanulvan, 7 ♂, 1 ?

RANGE.—From Cape Horn north to Ancud, Chile, and to the Rio Negro region, Argentina; migrating northward as far as the Buenos Aires region in winter.

SUBSPECIFIC CHARACTERS.—Similar to *T. m. chilensis*, but bill shorter (10–11 mm.) and more slender, the under tail-coverts usually unbarred.

This race has the ochraceous-tawny rump, upper tail-coverts and tail of *chilensis*, from which it differs in coloration only in having the lower tail-coverts usually without instead of usually with bars. In size the bill is noticeably shorter and more slender, but the wing averages longer.

Dr. Hellmayr writes that he has an “extreme” example of this race taken at Rosas, F. C. S. Buenos Aires, June 20, 1920, thus wholly confirming Daguerre’s record quoted under the preceding species.

Troglodytes cobbi Chubb

Troglodytes cobbi CHUBB, 1909, Bull. Brit. Ornith. Club, XXV, p. 15 (Falkland Islands).

SPECIMENS EXAMINED.—FALKLAND ISLANDS: Sea Lion Island, 1 ♂, 1 ♀; Kidney Island, 5 ♂, 2 ♀.

RANGE.—Falkland Islands.

SPECIFIC CHARACTERS.—Forehead and top of head ashy brown, turning to a warmer brown on lower back, rump and tail, the rump with a very slight rufescent tinge. Throat ashy brown turning to a warmer ochraceous brown on the flanks and belly with a very slight rufescent tinge on the under tail-coverts. Size very large, the wing and bill measurements similar to *T. musculus puna*, but tail averaging shorter.

While obviously a representative house wren, this bird is sharply distinct from any other in the very slight color contrast between the upper and underparts. It is almost as dark below as above. This fact in connection with its large size and insular habitat entitle it, in our opinion, to specific rank. It is rather surprising that it should have remained undescribed so long. Mr. Rollo H. Beck, who collected our series, writes that it lives in the dense tussock grass and has disappeared from all areas where sheep have been allowed to pasture.

MEASUREMENTS

			WING	TAIL	CULMEN
<i>Troglodytes aëdon parkmanii</i>	6 ♂		49. -54.5	40. -47.	11. -13.
	2 ♀		47. -50.5	42. -43.	13.
" <i>musculus peninsularis</i>	5 ♂		49.5-53.	37. -41.	12. -14.
" " <i>intermedius</i>	15 ♂		48. -52.	32. -38.5	12. -13.5
	3 ♀		48. -50.	35.5-36.	11. -12.5
" " <i>oreopolus</i>	11 ♂		48. -51.	32. -37.	11. -13.
	3 ♀		48. -48.5	33. -34.5	11.5-13.
" " <i>inquietus</i>	9 ♂		51. -54.	36. -38.	12.5-14.
	4 ♀		52.	36. -38.	13. -14.5
" " <i>atopus</i>	3 ♂		51. -52.	34. -37.	14. -14.5
	3 ♀		50. -51.	32. -37.	13. -14.
" " <i>striatulus</i>	20 ♂		52. -60.	38. -44.	13. -15.
	8 ♀		51. -56.5	38.5-42.5	13. -15.
" " <i>columbæ</i>	7 ♂		51. -56.	40. -43.	13.5-14.5
	4 ♀		52. -56.	39. -41.	14.
" " <i>albicans</i>	50 ♂		47.5-54.	30.5-40.5	12. -15.
	30 ♀		48. -53.	30.5-37.	12. -14.
" " <i>tobagensis</i>	2 ♂		58. -60.	39. -42.	14.5-15.5
" " <i>musculus</i>	21 ♂		49. -53.	37. -42.	13. -14.5
	8 ♀		49. -51.	38. -42.	13. -15.
" " <i>rex</i>	46 ♂		51. -57.	41. -49.5	12. -13.5
	24 ♀		49. -57.	40. -48.	12. -13.
" " <i>carabayæ</i>	13 ♂		47. -56.	38. -44.	12. -14.
	6 ♀		47.5-52.5	38. -44.5	12.5-14.
" " <i>puna</i>	13 ♂		53. -61.	43. -52.	13. -15.
	14 ♀		51. -59.5	42. -50.	13. -14.
" " <i>audax</i>	35 ♂		48. -54.5	36. -42.5	12. -14.
	12 ♀		48.5-54.	36.5-41.	12.5-14.
" <i>tecellatus</i>	14 ♂		50. -55.	36. -41.	12. -14.5
	4 ♀		50.5-54.	38. -42.	14.
" <i>musculus chilensis</i>	17 ♂		48.5-54.5	42. -47.	12. -13.5
	12 ♀		48.5-53.	40. -45.5	12. -13.
" " <i>bonariæ</i>	11 ♂		49. -53.5	39. -45.	12. -13.
	4 ♀		49.5-50.	39. -44.	12. -13.
" " <i>magellanicus</i>	10 ♂		50. -53.5	41.5-45.5	10. -11.5
	2 ♀		50. -51.	44.	11.
" <i>cobbi</i>	7 ♂		55. -60.	39. -43.	15. -16.
	3 ♀		55. -58.	40. -41.	14.5-16.

Article V.—FURTHER NOTES ON PTILOSIS

BY W. DEW. MILLER

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Since the publication of 'Notes on Ptilosis, with Special Reference to the Feathering of the Wing' in 1915,¹ numerous additional notes on the subjects there treated have accumulated. These are presented in the present paper. As before, Gadow's very useful table in Bronn's 'Klassen und Ordnungen des Thier-Reichs (Vögel, Systematischer Theil)' has been used as a basis of reference. Where Gadow's notations err in whole or in part or where other important works of reference such as Ridgway's 'Birds of North and Middle America' show that certain errors are still prevalent it has seemed well to call attention to them here.

EUTAXY AND DIASTATAXY

In my previous paper the Megapodidæ were listed as universally diastataxic, the Anhimidæ as comprising both eutaxic and diastataxic forms. The reverse is true in each case. *Megapodius* (two specimens of *M. reinwardti* and one of *M. cumingi* examined) and *Megacephalon* are diastataxic; *Leipoa* and *Alectura* (*Catheturus*) (one of each of the last three genera examined) are eutaxic.²

Anhima (*Palamedea*) was recorded by me as eutaxic on the published authority of Beddard and Mitchell, but I have since examined

¹Bull. Amer. Mus. Nat. Hist., XXXIV, pp. 129-140.

²*Megapodius* and *Megacephalon* also agree in the presence of a small oil-gland tuft, wanting in *Leipoa* and *Alectura*.

That these resemblances indicate a close relation between *Megapodius* and *Megacephalon* is doubtful for they are very different in many respects, as in the form of the bill and head, scutellation of the tarsus, size of the two-webs, length and form of the claws, number of rectrices (12 and 18 respectively), and in nidification. Allowing for the close affinity of *Eulipoa* with *Megapodius*, both the latter and *Megacephalon* are very unlike any other members of the family. The arrangement of the webs of the toes in *Megapodius* is unique. In other birds with only one web it is between the third and fourth toes, while in *Megapodius* there is a small basal web between the second and third toes and no trace of one between the third and fourth.

three specimens of the horned screamer and can state positively that this species, like *Chauna*, is diastataxic. Of the latter genus three specimens of *C. chavaria* and two of *C. cristata* have been determined.

The appended list of Columbæ, arranged according to the nature of the secondary remex series, brings our knowledge of this feature in the pigeons up to date. The genera *Vinago*, *Turturæna*, *Calopelia*, and *Tympanistria* are given on the authority of Mr. George L. Bates (1918, *Ibis*, pp. 554–556). The numbers preceding the names are those of the genera in Sharpe's 'Hand-List.'

DIASTATAXIC

Treronidæ

- | | | | |
|---|--------------------------------|----|-----------------------------------|
| 1 | <i>Sphenocercus sphenurus</i> | 11 | <i>Lamprotreron superba</i> |
| 2 | <i>Vinago calva</i> | 13 | <i>Ptilopodiscus coronulatus</i> |
| 5 | <i>Treron nipalensis</i> | 15 | <i>Chlorotreron iozona</i> |
| 6 | <i>Osmotreron bicincta</i> | 17 | <i>Sylphitreron aurantiifrons</i> |
| | “ <i>vernans</i> | 28 | <i>Muscadivores concinna</i> |
| 8 | <i>Leucotreron occipitalis</i> | 35 | <i>Myristicivora spilorhoa</i> |

Columbidæ

- | | | | |
|---|-------------------------------|---|-------------------------------|
| 2 | <i>Lithænas livia</i> | | <i>Ænænas nigrirostris</i> |
| | <i>Stictænas arquatrix</i> | 4 | <i>Turturæna iriditorques</i> |
| | <i>Chlorænas flavirostris</i> | 6 | <i>Macropygia emiliana</i> |
| | “ <i>rufina</i> | 9 | <i>Ectopistes migratorius</i> |
| | <i>Columba palumbus</i> | | |

Peristeridæ

- | | | | |
|---|--|----|----------------------------|
| 1 | <i>Zenaidura macroura</i> | 20 | <i>Æna capensis</i> |
| 2 | <i>Zenaida zenaida</i> | 23 | <i>Chalcophaps indica</i> |
| 5 | <i>Amoropelia turtur</i> (<i>Turtur</i>) | 33 | <i>Leptotila verreauxi</i> |
| 7 | <i>Streptopelia bitorquata</i> | 35 | <i>Oreopeleia montana</i> |
| | “ <i>capicola</i> | | “ <i>albifacies</i> |
| | “ <i>vinacea</i> | 42 | <i>Calænas nicobarica</i> |
| 9 | <i>Spilopelia chinensis</i> | | |

Gouridæ

- | | |
|---|-----------------------|
| 1 | <i>Goura victoria</i> |
|---|-----------------------|

Didunculidæ

- | | |
|---|---------------------------------|
| 1 | <i>Didunculus strigirostris</i> |
|---|---------------------------------|

EUTAXIC

Peristeridæ

- | | | | |
|----|---|----|---------------------------------|
| 11 | <i>Geopelia tranquilla</i> | 26 | <i>Phaps chalcoptera</i> |
| | “ <i>striata</i> | 27 | <i>Histriophaps histrionica</i> |
| | <i>Stictopeleia cuneata</i> | 30 | <i>Lophophaps leucogaster</i> |
| 12 | <i>Scardafella inca</i> | | “ <i>plumifera</i> |
| 14 | <i>Columbina picui</i> | 31 | <i>Ocyphaps lophotes</i> |
| 15 | <i>Chæmepelia minuta</i> | 36 | <i>Gallicolumba luzonica</i> |
| 18 | <i>Claravis pretiosa</i> | | “ <i>rufigula</i> |
| 21 | <i>Tympanistria tympanistria</i> | | “ <i>jobiensis</i> |
| 22 | <i>Turtur afra</i> (<i>Chalcopelia</i>) | 38 | <i>Leucosarcia picata</i> |
| 24 | <i>Calopelia puella</i> | 41 | <i>Starnænas cyanocephala</i> |

Salvadori's arrangement ('Catalogue Birds British Museum') is used in the table as a matter of convenience. The classification of the pigeons is a difficult problem and no satisfactory scheme has yet appeared.

It will be observed that all the eutaxic forms are in the Peristeridæ. The Treronidæ and Columbidae are universally diastataxic so far as determined. *Goura* and *Didunculus* are also diastataxic and this is true of the first two subfamilies of Peristeridæ (Zenaidinæ and Turturinæ) so far as they are known. All the Notogean groups of Peristeridæ (Geopeliæ, part of Phabinæ, and part of Geotrygoninæ) are eutaxic, contrasting with the other groups characteristic of the Australian Region (Treronidæ, Gouridæ, Didunculidæ), which are diastataxic. *Calænas* (diastataxic), while considered by Salvadori as forming a subfamily of Peristeridæ, is a very aberrant form and its curious range is neither distinctively Oriental nor Australian.¹

Until recently the Rallidæ have been considered as a wholly diastataxic family. Bates in 1918 recorded *Himantornis* as eutaxic and two

¹The condition of the wing as regards the fifth secondary has never been utilized taxonomically in this order for, until Mitchell's discovery that *Columbula* (*Columbina*) is eutaxic, the pigeons were supposed to be diastataxic throughout. Many genera remain to be determined in this and other characters and until this is done no final classification can be attempted. Enough data are at hand, however, to indicate the probably artificial nature of Salvadori's fourth and fifth subfamilies of Peristeridæ (Phabinæ and Geotrygoninæ). The members of these two groups characteristic of the Australian Region (i.e., Notogean) agree in having more than twelve rectrices and in being (so far as determined) eutaxic. The first five genera of Phabinæ form a natural group (all Ethiopian except *Chalcophaps*) of smaller birds with only twelve rectrices, some eutaxic and others diastataxic.

In the Geotrygoninæ the three American genera, *Leptotila*, *Osculatia*, and *Geotrygon*, have only twelve rectrices and (at least the first and third) are diastataxic. The remaining American genus, *Starnænas*, has twelve rectrices, is eutaxic, and is remarkably characterized in several respects. The New World genera (*Osculatia* unknown) have small intestinal cæca, while these are wholly wanting in the Australian genera (of these two subfamilies) examined. In fact, the absence of cæca in Notogean pigeons in general is so nearly a constant feature that *Gallicolumba* (*Phlegænas*) is the only known exception. They have, however, also been lost in many non-Australian genera of Peristeridæ.

Salvadori's characters separating the Phabinæ from the Geotrygoninæ are the presence of metallic spots on the wings in the former (absent in latter), and the stouter form, longer, stouter tarsi and shorter wings of the latter. But there is no definite line between the two groups in the tarsal characters, for in *Geophaps* (Phabinæ) the tarsi are relatively as long and stout as in *Leucosarcia* (Geotrygoninæ).

The Geopeliinæ also is probably an unnatural group. The two American genera, *Scardafella* and *Gymnopelia*, differ from the Australian Geopeliæ, and agree with the purely American subfamily Peristerinæ, in having but twelve rectrices and black under wing-coverts. The Geopeliæ agree with the other Australian Peristeridæ in having more than twelve rectrices. Furthermore, *Geopelia* lacks the ambiens muscle which is present in the two genera of Peristerinæ in which this character is known. Unfortunately, it has not been determined in *Scardafella* or *Gymnopelia*.

The prevalence of fourteen or more rectrices in the pigeons of the Australian Region, to whatever family they belong, is very striking and has hardly an exception, while all Eurasian and Ethiopian Columbidae and Peristeridæ, and all American pigeons except *Zenaida* and *Zenaidura*, have but twelve tail-feathers.

The remarkable Nicobar pigeon (*Calænas*), with its anomalous range, is diastataxic, and has twelve rectrices, in which combination it differs from all other Old World pigeons except the curious Philippine genus *Phapitreron* (if the latter is diastataxic as assumed), and probably a few other fruit pigeons.

It is generally recognized that the Peristeridæ cannot be regarded as more than a subfamily of the Columbidae. Blanford denies them even this rank, at least so far as the relation of the Turturinæ (of Salvadori) to the Columbidae is concerned. He also reduces the Treronidæ to subfamily rank.

It appears, then, that the changes that must eventually be made in Salvadori's arrangement will include the union of the Notogean members of the Phabinæ and Geotrygoninæ in one subfamily, which will probably include *Geopelia* also; and the transfer of *Scardafella* and *Gymnopelia* to the Peristerinæ. Not only do the characters justify these changes but the groups become much more plausible from the viewpoint of geographic distribution.

In 'The Birds of North and Middle America' (Part 7, p. 282) *Eupelia* and *Chæmepelia* are given as diastataxic ("aquinto-cubital"). The latter, at least, is eutaxic, and it is probable that Mr. Ridgway intended to use this character on the succeeding page to separate *Claravis* (eutaxic) from *Leptotila* (diastataxic).

species of *Sarothrura* as incompletely so. Through the kindness of Mr. James P. Chapin I am able to record for the first time three or four other eutaxic genera. The genera determined by Mr. Chapin are marked by an asterisk. The others are from my own notes, except *Himantornis hæmatopus* recorded by Bates.

It will be noticed that all the gallinules and coots thus far examined (genera Nos. 46 to 55) are diastataxic. Also that *Creciscus leucopyrrhus* differs from *C. coturniculus* and *C. (Rufirallus) melanophaius*. Mr. Ridgway remarks in describing his genus *Limnocrex* (type, *Creciscus cinereiceps*) that *C. leucopyrrhus*, which he had not seen, might possibly be referable to it.

Sarothrura is of special interest owing to the variations in this feature not only between the species but within specific limits. Bates recorded two species, *S. böhmi* and *S. rufa bonapartei* (a single specimen of each), as diastataxic as regards the upper coverts, eutaxic as regards the lower coverts. One of the two specimens of *S. rufa elizabethæ* determined by Mr. Chapin was likewise partially diastataxic, while the other one was completely so. The same inconstancy was found in the two skins of *S. lugens* examined. *S. insularis* and *S. elegans* were found to be completely diastataxic, while *S. pulchra* was perfectly eutaxic.

So far as known, the only other bird genera (taking Sharpe's 'Hand-List' as the standard) that include both types of wing are *Ceryle*, *Halcyon*, and *Chætura*. *Chlororceryle* is, however, amply distinct from *Ceryle*; *Streptoprocne* is very different from *Chætura*; and *Halcyon* is a composite group which at present is often broken up. *Sarothrura* is a more difficult problem owing to the intermediate nature of some of the species in this character. The taxonomic value of this feature in *Sarothrura* is comparable to that of the relative development of the tenth primary in *Vireosylva* and *Lanivireo*.

RALLIDÆ

Diastataxic

1	<i>Rallus virginianus</i>	*33	<i>Sarothrura</i> pt.
3	<i>Hypotænidia philippensis</i>	*36	<i>Coturnicops noveboracensis</i>
10	<i>Aramides albiventris</i>		" <i>notata</i>
	" <i>ypecaha</i>	*37	<i>Poliolimnas cinereus</i>
13	<i>Ocydromus</i> sp.	*38	<i>Porzanula palmeri</i>
*19	<i>Canirallus oculus</i>	*39	<i>Creciscus coturniculus</i>
20	<i>Rallina euryzonoides</i>	*	<i>Rufirallus melanophaius</i>
30	<i>Porzana carolina</i>	*41	<i>Limnocorax niger</i>
	<i>Porzanoidea tabuensis</i>	46	<i>Microtribonyx ventralis</i>
	<i>Nesophylax ater</i>	49	<i>Gallinula frontata</i>
*31?	<i>Pennula ecaudata</i>		" <i>galeata</i>

Diastataxic (continued)

50	<i>Porphyriops melanops</i>	*54	<i>Notornis alba</i>
52	<i>Ionornis martinica</i>	55	<i>Fulica atra</i>
53	<i>Porphrio calvus</i>		" <i>americana</i>
	" <i>poliocephalus</i>		" <i>leucoptera</i>

Eutaxic

*4?	<i>Nesolimnas dieffenbachi</i>	*	<i>Anurolimnas hauxwelli</i>
17	<i>Himantornis hæmatopus</i>	*33	<i>Sarothrura pulchra</i>
*	" <i>whitesidei</i>	*34	<i>Rallicula forbesi</i>
*28	<i>Anurolimnas castaneiceps</i>	*39	<i>Creciscus leucopyrrhus</i>

To the growing list of eutaxic forms can now be added the remarkable Madagascan group comprising *Mesitornis* and *Monias*. Mr. Chapin has shown the relationship between these two genera and determined that both are eutaxic.

Dr. P. R. Lowe has recently proved that the African genus *Ortyxelos* is a Hemipode allied closely to *Turnix*. Like the latter it is (according to Lowe) eutaxic, these two genera differing in this respect from the very distinct Australian genus *Pedionomus*, which Gadow states is diastataxic.

In the list published in my former paper the sun bittern (*Eurypyga*) was, by a careless error, placed with the other aberrant gruiform birds among the eutaxic forms. A fresh specimen of each species shows that this genus is typically diastataxic, thus differing from the Cariamidæ, Psophiidæ, Rhinocetidæ and Mesitornithidæ and agreeing with the true cranes, the bustards and most of the rails.

The diurnal birds of prey (Falconiformes) and the parrots (Psittaci) are without exception, so far as known, diastataxic. As examination of the smallest member of each group—*Microhierax* and *Micropsitta* (*Nasiterna*)—proves them to be diastataxic, it is altogether likely that there is no exception in either order. This is the more probable because the character has been determined in numerous genera of each group including virtually all the main types.

All of the families of Steganopodes are diastataxic but there is an exception in the Phalacrocoracidæ. A specimen of the flightless cormorant (*Nannopterum harrisi*) recently studied in the flesh was typically eutaxic, that is, on both dorsal and ventral surfaces of each wing. It will be of interest to determine this character in *Pallasicarbo*.

It is now clear that both styles of wing are found in the swifts. Sclater's statement that the tree swifts (Hemiprocnidæ) are eutaxic is erroneous, for Pycraft has recorded *Hemiprocne mystacea* as diastataxic. My own observations confirm Pycraft and show that *H. longipennis* and

H. comata also are diastataxic, and H. L. Clark has recorded that *H. coronata* is the same.

The true swifts include both types. Clark records *Cypseloides* (*Nephæcetes*) *niger* and *Streptoprocne zonaris* as diastataxic and, as regards the latter, two specimens examined by me confirm this. The following are eutaxic: *Collocalia*, *Chætura pelagica*, and *Hirundapus caudacuta* of the Chæturinæ; *Tachornis parva*, *Aëronautes melanoleucus* and *Micropus melba*, *M. æquatorialis* and *M. caffer* of the Micropodinæ. Thus, all of the second subfamily so far examined are eutaxic. The latter (except *Hirundapus*) were recorded for the first time by Clark and as to *Chætura pelagica* I can confirm his determination. The *Hirundapus* was recorded by Pycraft. Selater gave *Collocalia* as diastataxic while Clark records it as eutaxic, so that more information is needed regarding this genus.

In my previous paper overlooking Clark's record of certain genera as diastataxic, it was stated that authors had universally given the hummingbirds as eutaxic. Clark found at least one trochiline hummingbird that was eutaxic in one wing, diastataxic in the other. With this exception, all the Trochilinæ and Lophornithinæ determined are diastataxic. I have already recorded two genera of Phœthornithinæ (*Phæthornis* and *Glaucis*) as eutaxic, and to these can now add *Eutoxeres*.

The appended list records the Trochilidæ so far as they have been determined regarding this character.

DIASTATAXIC

Trochilinæ

9	<i>Campylopterus hemileucurus</i>	49	<i>Oreotrochilus pichincha</i>
15	<i>Patagona gigas</i>	*52	<i>Eugenes fulgens</i>
26	<i>Chlorostilbon</i> sp.	*53	<i>Lampornis clemenciæ</i>
31	<i>Cyanophaia wagleri</i>	67	<i>Ensifera ensifera</i>
*32	“ <i>cæruleolavata</i>	70	<i>Boissoneana flavescens</i>
	<i>Thalurania colombica</i>	92	<i>Heliothryx</i> sp.
36	<i>Colibri iolotus</i>	*105	<i>Archilochus alexandri</i>
38	<i>Anthracothonax gramineus</i>	*106	<i>Selasphorus rufus</i>
*	“ <i>violicauda</i>	*	“ <i>platycercus</i>
40	<i>Chrysolampis elatus</i>	*110	<i>Orthorhynchus exilis</i>
*46	<i>Leucochloris albicollis</i>		

Lophornithinæ

115	<i>Lophornis helenæ</i>	<i>Lophornis magnifica</i>
	“ <i>ornatus</i>	

EUTAXIC

Phœthornithinæ

5	<i>Glaucia hirsuta</i>	7	<i>Eutoxeres aquila</i>
6	<i>Phæthornis guyi</i>		

The species recorded by Clark are marked by an asterisk. No. 32, *Cyanophaia cæruleolavata*, was found to be eutaxic in one wing.

In this list Ridgway's division of the Trochilidæ into three sub-families has been followed but I doubt that the Lophornithinæ can be maintained. One of the characters of this group is the conspicuously narrowed outer web of the ninth (next to outermost) primary, but *Discosura* (which was apparently not examined by Ridgway in this connection), while closely allied to *Popelairia*, has a normal ninth primary.

The following lists bring up to date our knowledge of this subject, so far as regards the distribution of diastataxy and eutaxy throughout the class.

1. UNIVERSALLY DIASTATAXIC

Pygopodes (Loons; Grebes)	Otides (Bustards)
Tubinares (Petrels, Albatrosses)	Lari (Gulls)
Herodiones (Hérons, Storks)	Alcæ (Auks)
Phoenicopteres (Flamingoes)	Pterocletes (Sand-grouse)
Anseres (Swans, Ducks, Geese)	Psittaci (Parrots)
Anhimæ (Screamers)	Striges (Owls)
Accipitres (Hawks, Vultures, Secretary-bird)	Caprimulgi (Oil-bird, Frog-mouths, Nightjars)
Grues veri (True Cranes, Limpkin)	Coraciæ (Rollers). ¹

2. GROUPS CONTAINING BOTH EUTAXIC AND DIASTATAXIC FORMS

Megapodiidæ (Mound-builders) <i>Megapodius</i> and <i>Megacephalon</i> diastataxic; <i>Leipoa</i> and <i>Alectura</i> eutaxic.	Grues aberrantes. Sun-bittern, diastataxic; Seriema, Trumpeter, Kagu, eutaxic.
Columbæ (Pigeons) Treronidæ, Gouridæ, Didunculidæ, diastataxic; rest varied.	Steganopodes (Cormorants, Pelicans, etc.) <i>Nannopterum</i> eutaxic; all others diastataxic.
Ralli (Rails, Fin-foot) Most Rallidæ, diastataxic; rest and Heliornithidæ, eutaxic.	Halcyones (Kingfishers) Several genera of each style.
Limicolæ (Plovers, Snipe, etc.) <i>Philohela</i> alone known to be eutaxic.	Micropodii (Swifts) Hemiprocnidæ, diastataxic; Chæturinæ varied; Micropodinæ, eutaxic.
Turnices (Hemipodes) <i>Pedionomus</i> , diastataxic; <i>Turnix</i> and <i>Ortyxelos</i> , eutaxic.	Trochili (Hummingbirds) Phœthornithinæ, eutaxic; all others diastataxic.

3. UNIVERSALLY EUTAXIC

Struthiones (Ostrich)	Gallinæ alectoropodes (Grouse, Partridge, Pheasants)
Rheæ (Rheas)	Opisthocomi (Hoatzin)
Tinami (Tinamous)	Mesitornithes (<i>Mesitornis</i> , <i>Monias</i>)
Cracidæ (Curassows)	

¹Recent examination of a skin of *Coracopitta pittoides* and one of *Brachypteracias leptosomus* proves that the grand rollers are, like the typical rollers, diastataxic.

3. UNIVERSALLY EUTAXIC (*continued*)

Coccyges (Cuckoos; Turacos)
 Meropes (Bee-eaters)
 Momoti (Motmots, Todies)
 Trogones (Trogon)
 Bucerotes (Hornbills, Hoopoes)

Colii (Mouse-birds)
 Picariæ (Jacamars, Barbets, Wood-
 peckers, etc.)
 Passeres (Broad-bills, Tyrant-birds, Ant-
 birds, Lyre-birds, Song-birds, etc.)

FIRST PRIMARY COVERT

Little can be added to the statement in my previous paper that the greater upper covert lying between the inner two primaries is reduced only in certain alectoropodous Gallinæ, in *Turnix*, and in most parrots.

In the vast majority of birds, including all types of wings, even the weak-winged rails, small passerres, and hummingbirds, this feather is perfectly normal in all respects or at most slightly reduced in size. Except for the groups first mentioned above, the proximal covert is less than three-fourths as long as the next one only in a few pigeons (*Columba*, *Macropygia* and *Streptopelia*, but the reduction neither marked nor constant) and in *Rhinocetus jubatus*, in which the feather equals three-fourths in one bird, and is slightly less than three-fourths in the other specimens examined.

In the higher Gallinæ the covert averages about three-fourths, being always less than this in the three genera of grouse examined, and equal to or more than three-fourths in *Pavo* and the Numididæ, the other groups averaging intermediate. In the Gallinæ and in *Turnix* the covert is always pennaceous, at most slightly frayed along the edges, and, with the exception of a single specimen of *Francolinus francolinus*, it is always decidedly more than half as long as the second covert.

The parrots are of particular interest as regards this covert, being the only group of birds in which it is ever reduced to a true vestige or even absent. There is little or no reduction in the Cacatuidæ, Strigopidæ, Nestoridæ, and in *Psittichas* (*Dasyptilus*). In these the first covert is at least 70% of the length of the second. It is distinctly better developed in *Leptolophus* (*Calopsitta*) than in any other member of the order, usually more than 90% of the length of the next covert and perfectly normal in form and texture.

In the Platycercinæ (excluding *Lathamus*, i.e., *Nanodes discolor*, which certainly is not a member of this group) the covert is distinctly though not greatly reduced, averaging scarcely less than 70% of the second covert, and in the single specimen of *Micropsitta* (*Nasiterna*) examined it was exactly 70%.

In the Psittacinæ (excluding *Psittrichas*) it is less than 70%, except in one specimen of *Coracopsis nigra* in one wing of which it was 75% and perfectly pennaceous. In all other Psittaci it is less than 70%, except for *Amazona imperialis*, of which a single specimen has been examined. This includes all American parrots, the Paleornithinæ and the Trichoglossidæ (including *Lathamus*).

The covert is most reduced in the Arinæ (Conurinæ), in which it is frequently a downy vestige less than one-third the length of the next, and is often completely wanting in *Eupsittula*, *Pyrrhura* and allied genera.¹

VESTIGIAL ELEVENTH PRIMARY

The remicle is normally present in the Tubinares, including *Oceanites*, *Pelagodroma*, *Fregetta*, and *Prion*. The single specimen of *Oceanodroma melania* examined had a remicle 10.5 mm. long, but in *Oceanodroma leucorhoa* (several wings examined) there was no trace of this small quill.

The remicle is a constant feature in the Alcidæ and Laridæ. In the allied group, Limicolæ, it has been lost in two groups, the painted snipes (*Rostratula* and *Nycticryphes*) and the jacanas (at least in *Jacana spinosa*). In the true cranes, Gruidæ, the eleventh quill has been lost in *Balearica* (two specimens of *B. pavonina* examined). I can confirm Gadow's record of the presence of only ten primaries in all the aberrant gruiform birds (*Cariama*, *Psophia*, *Eurypyga*, and *Rhinochetus*) but he erroneously gives *Aramus* as having eleven, whereas in the three specimens examined (two from Florida and one from Nicaragua) there were only ten quills. In both *Mesitornis* and *Monias* there are ten functional primaries and no eleventh quill.

The Rallidæ is a group in which the remicle is at best extremely vestigial and is often wholly wanting. It does not appear to be generally known that in certain small flightless rails there is a reduction in the number of large primaries. In *Porzana* (*Nesophylax*) *atra* and *Pennula ecaudata* the tenth quill is wanting and the ninth is even shorter than the first. *Porzanula palmeri* has only eight primaries, the eighth equalling or slightly longer than the first. A single specimen of each of the last two species was examined by Mr. Chapin, and I am indebted to him for the privilege of recording this information.

¹Mathews and Iredale have made the cockateel (*Leptolophus*) a monotypic family, Leptolophidæ, which they place in the superfamily Psittaculoidea, associated with Pezoporidæ, Platycercidæ, Polytelidæ and Psittaculidæ (Paleornithidæ olim). Heretofore *Leptolophus* has usually been placed with the cockatoos (Cacatuidæ), with which it agrees in the doubly complete orbital ring, powder-down patches, gall-bladder, crest, and coloration. The complete development of the first primary covert is additional evidence that this position is the correct one.

The storks (Ciconiidae) have eleven large primaries. The remicle which is homologous with that of birds with ten functional quills is usually present, but I failed to find it in the three specimens of *Anastomus lamelligerus* examined. Neither could it be found in a skin of the shoe-bill, *Balæniceps rex*, but Dr. P. Chalmers Mitchell records it in a bird studied by him, so that examination of additional specimens is desirable.

Among the herons (Ardeæ) the remicle, which is usually well-developed, is entirely absent in the boatbill (*Cochlearius*, two specimens). It is unusually small and degenerate in *Botaurus lentiginosus* and *Ixobrychus exilis*. In *Doriponus* (*Agamia*) it is very small, apparently sometimes wanting, and is doubtfully present in *Gorsachius*.

The remicle is unusually large in many diurnal birds-of-prey (*Falconiformes*), notably in the condors, vultures, *Serpentarius*, *Terathopus*, *Aquila*, *Spizaetus bellicosus*, and *Pandion*. The other extreme is reached in *Accipiter*, *Ictinia* and the Polyborinæ. Although the remicle is normally present in a very degenerate condition in *Accipiter velox*, no certain trace of it could be found in any of the four specimens of *A. cooperi* examined. In the one *Ictinia plumbea* there was, in one wing only, a tiny vestigial feather that may have represented the eleventh quill. The two examples of *Polyborus cheriway* determined had no remicle whatever, but in a skin of *P. plancus* there was a well-developed vestige 18 mm. long. In three specimens of *Ictyter* (two of *I. megalopterus* and one of *I. ater*) no eleventh remex could be found. Apparently, therefore, this quill is usually absent in the Polyborinæ. In the smallest form of the order, *Microhierax* (*M. fringillarius* and *M. erythrogonys* determined), the remicle is very small but distinct.

In the owls (*Striges*) a small remicle is normally present but in the two specimens of *Glaucidium* (*G. brasilianum* and *G. siju*) examined not only the eleventh remex but the eleventh lower covert as well was absent. Bates, however, records the quill as present in his one example of the African *G. sjöstedti*, and both the remicle and the eleventh lower covert are constantly present in the Asiatic *G. cuculoides*.

The Caprimulgi (including Podargidae) are given by Gadow as having but ten primaries. H. L. Clark states (1901, Auk, p. 168) that the specimen of *Podargus* described by him had but ten. Sclater (1866, Proc. Zool. Soc., p. 581) also gives ten, "of which three are on the metacarpus," but this statement, which is perpetuated by Hartert in the British Museum Catalogue, is an obvious error for no bird with a normal wing has fewer than six metacarpal remiges. The single fresh specimen of *Podargus strigoides* examined by me had a pennaceous remicle 25 mm.

long. There was no greater under covert on the distal side of the tenth primary and for this reason special care was taken to assure myself that this small feather was actually the remicle and not a covert. This is strongly indicated by the position of the feather on the edge of the wing, close to the upper covert, by its form and texture, and particularly by the fact that its calamus is decidedly longer than that of the outermost lower covert. Ordinarily, of the two feathers, the eleventh primary and the eleventh lower covert (which lies between the tenth and eleventh primaries), the remex is the first to be lost, but apparently in *Podargus*, as in the Alcedinidæ, the covert has been lost and the remicle retained.

In the swifts and ordinarily in the nightjars there is, exclusive of the upper covert, only a single small feather on the outer side of the tenth primary. In my notes a little doubt was expressed in the case of *Streptoprocne* and *Nyctidromus* as to the identity of this feather but, judging by other members of each family, I believe that it may safely be considered as the eleventh lower covert. However, in the Australian nightjar, *Eurostopodus mystacalis* (of which several skins have been examined), both the covert and the remicle are present, a rather surprising exception to the absence of the latter in the Caprimulgidæ. Thus the nightjars are moved a trifle nearer the owls and farther from the swifts.

Gadow credits the hornbills (Bucerotidæ) with eleven primaries, but in all those examined by me (*Bucorvus*, *Anthracoceros*, and *Lophoceros*) there are only ten, the remicle being absent.

Sundevall records eleven primaries in the turacos (*Musophaga* and *Corythaix*), but Gadow gives the number for the family as ten, and I have found but ten in *Turacus* and in *Crinifer* (*Chizærhis*) *concolor*.

That the remicle occasionally reappears in groups which normally lack it is shown by a specimen of the domestic fowl (*Gallus*) in which there was a small eleventh quill 14 mm. long. There was no eleventh lower covert. In a single specimen of *Argusianus grayi* and in one of *Numida galeata*, this eleventh covert (normally absent in all Gallinæ) was present, but no eleventh quill.

The remicle of eleven-primaried birds is homologous with that of twelve-primaried forms, in both of which it is the distal predigital. The remicle of ten-primaried birds (the so-called "9-Primaried" forms), however, is the proximal predigital and hence is merely analogous with that of other birds. In the "9-Primaried" Oscines this tiny quill is, so far as known, invariably present. Outside of the Oscines the Indicatoridæ is the only "9-Primaried" group, and probably some members of the family are nine-primaried in the strictest sense, for in two skins of

Prodotiscus the tenth primary is apparently wholly wanting. In most other honey guides the small quill is present, but even more reduced than in any of the Oscines.

FUNCTIONAL PRIMARIES

The number of primaries is, as is well-known, a very constant feature throughout large groups of birds, yet individual variation is not rare. Bates records a specimen of *Glaucidium sjöstedti* with eleven large primaries, and states that he had observed several cases of this abnormality in other orders. My notes include the following records.

Necrosyrtes pileatus, ten functional primaries in one wing, eleven in the other (the remicle also present in each wing). *Ixobrychus exilis*, ten large primaries in the left wing, eleven in the right (minute remicle apparently present in each wing). *Philohela minor*, ten large primaries in the left wing, eleven in the right (three outer quills in each wing shortened and greatly narrowed as usual in this species; the remicle, normally present, was not determined with certainty). In two cases, an ibis, *Carphibis spinicollis* and a parrot, *Alisterus cyanopygius*, there were in each wing only nine large primaries, with no evidence of loss by molt or accident. Special mention must be made of the remarkable variations in the number of primaries in the loons (*Gavia*). In the three specimens of *Gavia stellata* seen in the flesh the normal number of quills, ten large ones and the remicle, were present.

On the other hand, of the three fresh specimens of *G. immer* examined, no two had the same number of primaries. Excluding the remicle, which was always present, the numbers were: ten in each wing; eleven in each wing; eleven in one wing, twelve in the other. The last specimen was an October bird of the year, and it is the only case in which I have found two extra quills in the wing. It will be interesting to learn by examination of a large series to what extent the loons vary in this respect. While some of the birds with an abnormal number of remiges have been captive specimens, others were wild birds, and there is no reason to believe that the variations are induced by captivity.

The following table shows our present knowledge of the number of primaries throughout the class. The remicle is noted separately.

THE NUMBER OF PRIMARY REMIGES IN BIRDS

16

Struthionidæ

12

Rheidæ

11+1

Podicipitidæ

Ciconiidæ (11 in *Anastomus*)

Phœnicopteridæ

10+1

Gaviidæ

Tubinares

Steganopodes

Ardeæ (10 in *Cochlearius*)

Ibides

Anseres variable in *Nesonetta*

Anhimidæ

Cathartidæ

Accipitres (10 in *Accipiter* pt. and *Polyborinæ* pt.)

Ralli (exceptionally 9 or 8; remicle always small, sometimes absent)

Heliornithidæ

Gruidæ (10 in *Balearica*)

Otididæ

Limicolæ (10 in *Jacaniidæ* and *Rostratulinæ*)

Pteroclidæ (11th small)

Lari

Alcæ

Striges (10 in *Glaucidium* pt.)

Coraciidæ

Alcedinidæ

Meropidæ (11th very vestigial; 10 in *Meropinæ*)

Momotidæ

Caprimulgi (10 in all except *Podargus* and *Eurostopodus*)

Capitonidæ (doubtless 10 in some)

Ramphastidæ

Picidæ (10 in some groups)

Passeres pt. (10 in many; 9+1 in "9-Primaried" Oscines)

10

Scopus? *Balæniceps*

Crypturi

Galli

Turnicidæ

Meditornithidæ

Aramidæ

Cariamidæ

Eurypygidæ

Rhinochetidæ

Columbæ

Opisthocomi

Musophagi

Cuculi

Psittaci

Todidæ

Bucerotidæ

Upupæ

Coliidæ

Macrochires s. s.

Trogonidæ

Galbulæ

Indicatoridæ (10th vestigial, sometimes absent)

Passeres pt. (10th vestigial in "9-Primaried" groups)

ALULA

In my previous notes three genera, *Psophia*, *Tapera*, and *Chizærhis*, were recorded as being unique in having the first alula quill shorter than the second. This is so also but to a less degree in certain Rallidæ; in others the first two quills are equal, while in the coots and gallinules the first is always the longest feather. In the tinamous, certain cuckoos, and most turacos, the first and second quills are about equal.

In the Passeres the first alula quill always exceeds the second. The number of quills is almost universally three or four, five in *Gymnorhina* and *Struthidea*, and apparently six or seven in *Menura*, in which the first is scarcely longer than the second. In the Caprimulgidæ four is the typical number, and Clark is in error in recording¹ only three quills in each of the four genera of North American Caprimulgidæ studied by him.

OUTERMOST PRIMARY COVERT

No parallel to the remarkably enlarged outermost upper greater primary covert of the trumpeter (*Psophia*), previously recorded by me, has been found, but several cases of a moderate enlargement of this covert have come to light, namely in *Cariama*, *Chunga*, *Meleagris*, *Numida*, *Jacana*, *Cochlearius*, *Strigops*, *Centropus*, several genera of Tyrannidæ (as *Todirostrum*) and in *Smithornis* (the last recorded by Bates), in all of which the outer covert is somewhat longer than the next one. I have never found this covert altogether wanting (in eleven- or twelve-primary groups) but in many Gallinæ it is reduced to a vestige.

RECTRICES

There is considerable variation in the number of rectrices among the small crakes (Rallidæ) and this, when determined in all the species, may be useful in the delimitation of genera, particularly in connection with the presence or absence of the fifth secondary-covert. *Porzana carolina* has twelve tail-feathers, while in *P. flaviventris*, lately separated by Ridgway as *Hapalocrex*, there are ten. *Porzanoidea tabuensis* has ten, but *P. (Nesophylax) atra* has only eight. In *Coturnicops noveboracensis* and *Creciscus jamaicensis* there are ten rectrices, while *Creciscus viridis* (*cayennensis*) has only eight. In the remarkable African wood-rail, *Himantornis*, there are only eight rectrices.

As to *Psophia* Beddard states: "there are apparently ten rectrices (not twelve, as Nitzsch stated)." Three specimens of *P. crepitans* bear

¹1895, Proc. U. S. Nat. Mus., XVII, p. 553.

out Beddard's opinion; two of these had ten tail-feathers, the third only nine, but one apparently lost.

There is need of further investigation of the number of rectrices in the Ardeidæ. The bitterns, Botaurinæ, are supposed to be distinguished from the typical herons, Ardeinæ, by possessing only ten rectrices, as well as by having only two pairs of powder-down patches and differently proportioned feet and claws. *Zebrilus*, however, though a heron judged by its toes, claws, and three pairs of powder-down tracts, has only ten tail-feathers as in the bitterns. In certain of the smaller bitterns there are, as recorded by Beddard, only eight rectrices. This is true of *Ixobrychus exilis*, *I. erythromelas*, and *I. involucris*, but in the Old World members of the genus (excepting possibly the Australian *I. dubius*) there are ten rectrices. In one specimen of *I. minuta* and one of *Botaurus lentiginosus* I found the unusual number of eleven.¹ Beddard also records variation in *Botaurus*.

The owls (Striges) with the single exception of *Micropallas* are recorded as having twelve tail-feathers. Another exception is found in the Cuban *Gymnasio lawrencei*, which, like *Micropallas*, has but ten rectrices. This statement is based on three skins, and careful examination failed to show that any feathers were missing. There is no doubt however that the Porto Rican species, *G. nudipes*, has twelve rectrices, as shown by several specimens. *G. lawrencei* also differs from *G. nudipes* (type of the genus) in having the upper third of the tarsus densely feathered instead of having the tarsus almost wholly naked, and there are decided differences in coloration. Probably *G. lawrencei* should be generically separated under the name *Gymnoglaux* Cabanis.

So far as I am aware the cuckoos (Cuculidæ), with the exception of the Crotophaginæ, have ten tail-feathers. Beddard's statement (1898, 'Structure and Classification of Birds,' p. 272) that there are only eight in *Saurothera* is erroneous, the normal number being ten.

Pycraft (1907, Ibis, pp. 232 to 233) records ten rectrices in *Colius affinis*. This may be the full number in certain species of *Colius*, but in *C. striatus*, of which four skins are available, there are twelve.

As pointed out in my previous paper the motmots (Momotidæ), except *Momotus*, have normally but ten rectrices. Several exceptions, however, have been noted and evidently the number of tail-feathers in some of the genera at least is an unstable character. The exceptional specimen of *Baryphthengus ruficapillus* already recorded by me had six

¹It is possible that the absence of a vinculum between the two deep plantar tendons will prove to be a constant character of the Botaurinæ. Beddard records this feature in *Botaurus stellaris*, *Ixobrychus involucris*, and *I. exilis*. I have determined it in *Botaurus lentiginosus* and *Ixobrychus exilis*.

rectrices on one side of the tail (the other side being imperfect). A skin of *B. (Urospatha) martii semirufa* recently examined (Princeton Museum) has six rectrices on one side, five on the other (this evidently the full number, the fifth feather of one side being intermediate in length between the fifth and sixth of the opposite side). In *Eumomota superciliaris* also the number varies. Of twenty-four skins examined, twenty-two have ten rectrices, one has eleven (full number evidently) and one has twelve. In the last specimen (A. M. N. H. No. 143817), the outer pair of rectrices is, relative to the next pair, much longer than in *Momotus lessoni*, and even of considerably greater actual length than in the latter.

All of the several hundred known species of hummingbirds (Trochilidæ) have ten tail-feathers. The adult male of *Loddigesia mirabilis* is credited with only four, but Mr. Ridgway has suggested¹ that careful examination would probably reveal the apparently missing rectrices, and the surmise proves to be correct. Four specimens of this rare species have recently been acquired by the Museum, one of them an adult male with a perfect tail. In this bird I find the full number of ten rectrices. Those heretofore recognized are the first or central pair, which are only 12 mm. long and hidden by the coverts, and the greatly lengthened racket-like fifth or outermost pair. Crowded in between these quills are three vestigial rectrices, the innermost (second) 3.5 mm. long, the next (third) slightly smaller, and the outermost of the three only 2 mm. long. The vanes of these reduced rectrices are degenerate in structure but relatively broad.

Among the true woodpeckers (Picidæ s. s.) *Campephilus (Megapicos) pollens* remains the only exception to the presence of twelve tail-feathers. In an allied species, *Chrysocolaptes hæmatribon*, however, there is in one specimen examined an approach to *Megapicos* in the reduction of the outer rectrices, and one of the vestigial sixth pair has been suppressed. Beddard's record of only ten rectrices in *Tiga shorei* was based on an imperfect or abnormal bird, for the specimens examined by me have the full number.

There has been much confusion as to the number of tail-feathers in the piculets (Picumnidæ). Some of this is doubtless due to Sundevall, who recorded ten rectrices in those having twelve because he did not consider that the vestigial sixth pair counted as tail-feathers. In *Nesocittes* and in *Picumnus* (including *Vivia*) there are twelve rectrices exactly as in the wrynecks and woodpeckers. *Sasia* has lost the small sixth pair and has ten rectrices, while in *Verreauxia* still another pair

¹1892, 'The Hummingbirds,' Report of the U. S. Nat. Mus. for 1890, p. 300.

has been lost and there are only eight feathers. This statement is based on the series of this rare African piculet collected by Chapin, and in no specimen are there more than eight tail-feathers.

In many species of antpittas, *Grallaria* (including *G. rufula*), there are twelve rectrices. Mr. Ridgway has separated from true *Grallaria* a well-marked group of small species under the name of *Hylopezus*, but erroneously credits them with twelve rectrices as in *Grallaria*. Examination of about twenty-five skins of *H. intermedius*, *H. dives*, and *H. perspicillatus* fails to disclose more than ten rectrices in any bird.

The only American wren (Troglodytidae) credited with fewer than twelve tail-feathers is *Thryorchilus*. But there are only ten in *Henicorhina*, in *Microcerculus*, and in the smaller species of *Leucolepis*. The peculiar large species of the last named genus, *L. thoracicus*, has twelve rectrices.¹

Many cases of individual variation in the number of rectrices have been observed and will be recorded at some future time.

OIL-GLAND AND ITS TUFT

Gadow marks the oil-gland as tufted in all the families of gallinaceous birds, while Sharpe gives it as nude in Megapodiidae, feathered in the rest. In his key to the families of Gallinae Mr. Ogilvie-Grant ('Cat. Bds. Brit. Mus.') distinguishes the Megapodiidae from the Cracidae by this character.

There is no doubt that the oil-gland is perfectly bare in *Alectura* and *Leipoa*, but each of the two fresh specimens of *Megapodius reinwardti* (*duperreyi*) examined had a small circlet of feathers three millimeters long, and a vestigial tuft was also found in a mounted specimen of *Mega-*

¹*Leucolepis thoracicus* differs in several other respects from the four or five more typical species of the genus (the type of which is *L. musicus* = *L. arada*). Taken in connection with the difference in the number of rectrices, which in the Passeres is almost invariably a generic character, I believe that *L. thoracicus* should be generically separated and propose for it the name **Rhinorchilus**.

Rhinorchilus thoracicus is a somewhat larger bird than any of the species of *Leucolepis*, with proportionately larger bill and feet. The tail is relatively longer, much more than half as long as wing (instead of equal to or little more than one-half), of twelve instead of ten rectrices, the webs of which are more lax. The wing is relatively somewhat smaller with shorter tip, the eighth primary equalling or shorter than the first (innermost), instead of longer than the first (usually at least equal to the second, often equalling or exceeding the third, in *Leucolepis*).

The mesorhinium is more strongly compressed and elevated, the nasal depression running farther forward; the nostril nearer to the tomium than to the culmen (midway between or nearer the culmen in *Leucolepis*). Distal half of bill depressed rather than compressed, the culmen somewhat flattened and usually more abruptly decurved terminally, the tip of both maxilla and mandible broader and more obtusely rounded. Sides of head more densely feathered, no marked bare postorbital space. The bristly frontal and loreal feathers are more highly developed, being looser webbed, longer, and more erect (closely approached by *C. salvini*). The remiges and rectrices are uniform blackish-brown, unbarred, as are the wing- and tail-coverts. (In *Leucolepis* the wing-quills and their coverts and the tail-feathers are always barred.) This color distinction holds in juvenal plumage also.

R. dichrous is only a slight race of *R. thoracicus*. The distinct species of *Leucolepis* are *L. arada*, *L. phaeocephalus*, *L. lawrencei*, *L. modulator* and *L. salvini* (the latter perhaps a race of *L. modulator*). The generic name *Cyphorhinus* Cabanis, 1844, used until 1902 for this group, is preoccupied by *Cyphorhina* Lesson, 1843. The type of *Cyphorhinus* is *C. thoracicus*, and accordingly for those who consider a difference in gender ending a sufficient distinction *Cyphorhinus* will replace *Rhinorchilus*.

cephalon. Thus this feature, like that of the fifth secondary-covert, is variable in the Megapodiidæ. On the other hand in all the Cracidæ the tuft is virtually vestigial. In the two fresh specimens of *Ortalis vetula* examined the tuft was reduced to a tiny vestige only one millimeter long in one bird, while in the other bird the gland was apparently bare.¹

In the Rallidæ the oil-gland tuft is normally well developed. Although it is as large in the coots and in *Gallinula* as in any member of the family, it is small or even vestigial in *Porphyrio* and in *Ionornis martinica*. Furthermore, while large in *Ocydromus*, it is entirely absent in *Himantornis*. Thus this African wood rail, which is noteworthy in having only eight rectrices, a eutaxic wing and in having the aftershaft minute in some feathers and wholly absent in others, is, so far as we at present know, unique in the family in its nude oil-gland. Beddard is in error in recording the tuft as absent in *Porzana carolina* (1898, 'Structure and Classification of Birds,' p. 321).

Gadow gives the oil-gland of *Eurypyga* as bare; Beddard states that it is "generally nude but occasionally tufted." In each of my two fresh examples, one of each species, there was a small tuft present. In the strange passerine-like Madagascan genus *Monias* the oil-gland appears to be entirely absent.

Gadow records the oil-gland as tufted in all the Ardeæ and Beddard gives it as bare only in *Cochlearius*. There are, however, several exceptions among the true herons. I have found the tuft present in the following: *Pyrrherodias manillensis* (two birds, tuft fair sized), *Ardea melanocephala* (tuft very small), *Florida cærulea* (vestigial), *Nyctanassa violacea* (small), *Nycticorax nycticorax* and *N. caledonicus* (fair-sized), *Butorides virescens* and *B. stagnatilis* (fair-sized), *Tigrisoma lineatum* (small), *Heterocnus cabanisi* (fair-sized), *Botaurus lentiginosus* (small), *Ixobrychus exilis* and *I. involucris* (small). In the following species the tuft is wholly absent: *Ardea goliath*, *A. herodias*, *A. cocoi*, *A. occidentalis*, *Notophoxyx novæhollandiæ*, *N. pacifica*, *Egretta candidissima*, *Hydranassa tricolor*, *Cochlearius cochlearius*. In *Balæniceps* the tuft is very much larger than in any heron. This remarkable bird is also stork-like rather than heron-like in having a well-marked claw on the pollex.

Examination of three skins of the pigmy falcon (*Microhierax fringillarius*) reveals the first known exception in the Accipitres to the presence

¹These two families differ in the number of carotid arteries, in the development of the aftershaft and in the average relative length of the first secondary, but it is difficult to find any obvious and constant external difference between them. In the Megapodiidæ there are only four developed alula quills, whereas in the Cracidæ there are five or six or sometimes apparently even seven.

of an oil-gland tuft. In all three specimens the oil-gland is quite nude. In *Polihierax* the tuft is well developed.

Regarding the owls it is commonly stated that the oil-gland is bare except in the barn owls (*Tyto*) in which Nitzsch found a minute tuft. Beddard records a similar vestigial tuft in *Asio otus*. The following lists summarize my notes on this subject, one specimen of each species having been determined unless otherwise indicated. The species in which not the slightest trace of a tuft could be seen, even below a ten-power lens, are the following: *Rhinoptynx clamator*, *Ketupa ketupa*, *Ciccaba nigrolineata*, *Cryptoglaux acadica* (2), *Speotyto cunicularia* (2), *Glaucidium brasilianum*.

In the following species a vestige of the tuft could always be detected, with the exception of seven of the twelve examples of *Bubo virginianus* and one of the two *B. africanus*, in which the gland was absolutely bare: *Asio wilsonianus* (4), *Ketupa ceylonensis*, *Ninox boobook*, *Strix varia* (4), *Scotiaptex nebulosa*, *Bubo lacteus*, *Bubo bubo* (2), *Bubo virginianus* (12, only 5 with traces of tuft), *Bubo africanus* (2, only one with tuft); *Nyctea nyctea* (2); *Pulsatrix perspicillata*, *Otus asio* (9), *Otus choliba*, *Gymnasio lawrencii*, *Tyto pratincola* (6), *Tyto alba*.

The number of minute feathers forming the vestigial tuft varied from one to twelve, but even in the latter case (one specimen of *Asio wilsonianus*) the longest one was only one millimeter long. In *Ketupa ceylonensis* there was a single, virtually microscopic shred. My observations on *Tyto* confirm Nitzsch's statement that the gland invariably bears two tiny feathers. These average longer than in any of the Strigidae, in which the longest feather is rarely as much as two millimeters long. In *Bubo lacteus*, which is exceptional, it was four millimeters; in *Tyto* four and one-half.

The power of heredity to perpetuate these minute and apparently utterly useless vestiges through countless generations is surely most remarkable.

The oil-gland is invariably tufted in the honey guides (Indicatoridae), but the tuft is vestigial in *Prodotiscus*.

Since the publication of my previous paper I have examined the few genera of barbets (Capitonidae) and woodpeckers (Picidae) that were not available at that time. Among the African barbets a small tuft is present in *Trachylæmus purpuratus*, but none in *Trachyphonus* (*T. cafer*, *T. margaritatus*). *Gymnobucco* agrees with *Heliobucco*, as expected, in having a nude oil-gland. *Buccanodon duchaillui*, however, also lacks the tuft and differs thus from its supposedly nearest ally, *Pogoniulus* (*Xy-*

lobucco or *Barbatula*), in which the tuft is invariably present. This difference justifies us in recognizing *Buccanodon*, as was done by Reichenow on the basis of its larger hallux, although later Oberholser questioned its validity. There are several other differences between the two genera but these are the most important. *Viridibucco* (*V. simplex*, *V. leucomystax*) agrees with *Pogoniulus* in the presence of a small tuft, while in *Smilorhis kilimensis* and *Stactolæma anchietæ* this is absent.

To summarize the condition of the oil-gland in the barbets, we find the tuft invariably present in all American and Oriental genera (thin and sparse in the very distinct *Calorhamphus*, dense in the rest), and of the Ethiopian forms present in *Trachylæmus*, *Pogoniulus*, and *Viridibucco*. The tuft is absent in the following, all African: *Pogonorhynchus* (including *Erythrobucco*), *Melanobucco*, *Lybius*, *Tricholæma*, *Gymnobucco*, *Heliobucco*, *Smilorhis*, *Buccanodon*, *Stactolæma*, *Trachyphonus*.

Among the woodpeckers the presence of the tuft has been determined in *Trichopicus cactorum*, *Sapheopipo noguchi*, *Ceophlæus galeatus* and *Ceophlæus* (*Neophlæotomus*) *schulzi*. The tuft is usually absent in *Chrysocolaptes* (*Reinwardtipicus*) *validus*; present in about seven-eighths of the specimens of the various species of true *Chrysocolaptes*. There are no genera with constantly bare oil-gland, except the four Oriental genera already recorded, viz., *Dinopium* (*Tiga*), *Brachypternus*, *Gecinulus* and *Chloropicoides* (*Gauropicoides*).

In one group of African woodpeckers, however, the oil-gland itself has been entirely suppressed. This group comprises the following species of *Campethera*: *C. maculosa*, *C. permista*, *C. caroli*, and *C. nivos*¹. Because of this and other differences the genus *Campethera* should probably be restricted to these species, the others, including *C. tæniolæma*, which have a tufted oil-gland being referred to *Chrysopicos* (type *C. nubica*). This is the only known instance of the loss of the oil-gland in the Picariæ (antiopelmous birds), and the only other cases in the Coraciiformes are in the Caprimulgi (*Podargus* and *Nyctibius*).

Two more genera of parrots must be added to the five already known to have no oil-gland. These are *Anodorhynchus* and *Orthopsittaca*, several specimens of each of which have been seen. An excellent character is thus added to those distinguishing the latter genus from *Ara* and *Diopsittaca*. The five other genera lacking the gland are *Amazona*, *Pionus*, *Graydidascalus*, *Brotogeris* and *Tirica*. It will be noted that all seven genera are American.

¹This feature first observed by me several years ago has been discovered independently by Bates, but not yet published by him.

AFTERSHAFT

The *Apteryx* is rightly considered as lacking the aftershaft, yet this is not invariably so. In one bird of the streaked type three feathers were examined and all were perfectly simple. In a specimen of *A. mantelli* two of the three feathers examined were similar, but the third, a feather 90 mm. long (excluding calamus), had a minute vestige of an aftershaft 4 mm. long, a single shred with a few terminal barbs.

Gadow marks the aftershaft in the tinamous (Crypturi) as vestigial or absent. Beddard states that "it is apparently in the process of disappearing among the Tinamous," vestigial in *Nothocercus* and absent in *Tinamus solitarius*. My records also show that the aftershaft is vestigial in *Nothocercus* and *Tinamus*. In some specimens of the latter, the aftershaft is wholly absent (the web not even crossing shaft), at least in the few feathers examined; in other individuals while absent on certain feathers a small one was present on others, usually less than one-fourth as long as the feather, in one case somewhat more than one-third, but its rachis always short. In *Crypturus* and *Crypturellus* the aftershaft is somewhat better developed. In *Rhynchotus*, *Nothoprocta*, *Nothura* and *Calopezus*, it is very well developed, decidedly more than half to three-fourths the length of the feather, and with an excellent rachis, much resembling the aftershaft of a grouse or pheasant.¹

Beddard's statement that neither *Heliornis* nor *Podica* has an aftershaft is strictly true as to the former but not so regarding the latter. In several feathers from both dorsal and ventral surfaces of *Podica senegalensis* and *P. camerunensis* I find a small aftershaft varying from one-eighth to one-third as long as the feather, and with a short but distinct rachis. Other writers, including Gadow, have invariably recorded the aftershaft as absent in the sun-grebes.

Beddard, referring to the Steganopodes, states that "the aftershaft is minute but distinct in *Fregata*, apparently absent in *Plotus* and other genera." I have found no constant difference in this respect between any of the families of this order. In *Pelecanus* and *Anhinga* (= *Plotus*) the ventral side of the shaft is perfectly bare at its junction with the calamus; in *Sula*, *Phalacrocorax*, and *Phaëthon* the shaft is sometimes bare, sometimes crossed by a short fringe of barbs, and in *Fregata* this fringe appears to be a constant feature.

¹The division of the Crypturi into two subfamilies depending on the presence or absence of the hallux is purely artificial. There are many other characters to consider, such as the intestinal cæca, aftershaft, wing-formula, bill, powder-downs, rectrices, and tarsal scutellation. Of these the aftershaft is one of the most important.

There appears to be a difference of opinion as to whether any owls possess the aftershaft. Gadow gives it as absent or vestigial; Clark states that it is absent in the owls examined by him, including *Tyto*; Beddard says that "it is often given as a character of the owls that there is no aftershaft. There is, however, a small one in *Strix*" (i.e., *Tyto*). This disagreement may be due to a difference of opinion as to what constitutes an aftershaft. In all of the numerous genera of owls examined by me, including *Tyto*, I have found the web of each side of the feathers running down to the base of the shaft and completely across its ventral side, thus forming a fringe of barbs at the point from which the aftershaft springs, when present. Judging by intermediate stages noted in the Anseres this fringe is to be considered as a degenerate aftershaft although there is no common shaft whatever even at the extreme base. In the feathers of the barn owl (*Tyto*) examined (three specimens) I have found the same structure as in other owls.

Both Gadow and Beddard mark the aftershaft absent in the Alcedinidæ. This is so in *Alcedo ispida*, at least in six feathers from different parts of one bird, and in a specimen of *Ceryle rudis* (two flank feathers examined). In all other species studied however I have found a small but distinct aftershaft. This is the case in *Megaceryle torquata*, *M. alcyon* (usually one-seventh to nearly one-half length of feather), *Chloroceryle amazona* (more than one-third), *C. americana*, *C. inda* (more than one-half but very fine), *Ramphalcyon guri* (small), *Clytoceyx rex* (a small vestige), *Dacelo gigas* (3 specimens; in each case a small aftershaft on some feathers, none at all on others), *D. intermedia* (small on some feathers, absent on others).

It has been supposed that the hoopoes (Upupæ) lack the aftershaft. This is probably so in *Upupa*, of which one specimen has been examined and no trace of the aftershaft observed; but, to my surprise, a recently acquired fresh specimen of a wood hoopoe, *Phœniculus (Irrisor) erythrorhynchus*, showed a well-marked though very slender aftershaft on the feathers of all parts of the body. The rachis is very short and slender and the aftershaft is remarkably like that characteristic of the songbirds (Oscines). On an interscapular feather it was two-thirds as long as the feather, and on a rump feather 26 mm. long, the accessory plume was 22 mm.

Ridgway (1914, 'Bds. N. and M. Amer.,' part VI, p. 2) uses the aftershaft to distinguish between the barbets (Capitones) and the toucans (Ramphastides), stating that it is present in the former, wanting or rudimentary in the latter. This is evidently taken from

Gadow's table of characters. No such distinction can be made, for after examining the feathers of several genera of each group I can not find even a definite average difference between them. The aftershaft of both is essentially like that of the woodpeckers, and these are all decidedly oscine, but more luxuriant and with a distinctly better developed rachis than in the latter type. In the toucans the aftershaft is sometimes actually as long as the main feather. Gadow marks the aftershaft as vestigial in the Picidæ. This may be considered correct as regards its structure, but in the piculets it is nearly or quite as long as in the toucans, and little shorter in the true woodpeckers.

Again in the Caprimulgi Gadow gives this secondary plumule as vestigial or absent, but in the typical nightjars and in *Ægotheles* the aftershaft though shorter than in woodpeckers is much less degenerate in structure. It is often two-thirds as long as the feather, with a rachis more than half its own length.

As regards the aftershaft "in the aberrant *Steatornis* it is not absent (as Garrod asserted)" (Beddard). We shall agree with Garrod or with Beddard according as we regard the fringe of barbs at the base of the shaft as an aftershaft or not. In the feathers examined from various parts of the body of several specimens of the oil-bird, the structure is exactly as in the owls, the independent barbs crossing the shaft and continuous with the lateral barbs of the feather. In both *Podargus* and *Batrachostomus* there is a true aftershaft, more degenerate than in the Caprimulgidæ, particularly in *Podargus*.

The following is a provisional list of the groups in which the aftershaft is wholly absent or is represented by a well-marked fringe of independent barbs. In all other groups of carinate birds there is a true aftershaft although it is often small or very degenerate in structure.

AFTERSHAFT ABSENT

Struthionidæ	Bucerotidæ
Rheidæ	Upupidæ (excluding Phoeniculidæ)
Steganopodes (slight fringe crosses shaft in some)	Bucconidæ
Anhimæ (slight fringe crosses shaft in some)	Menuridæ
Columbæ	Eurylæmidæ
Cuculidæ	Clamatores (except <i>Acanthisitta</i> ; rarely a trace in Tyrannidæ)
	Oscines (a few genera)

WELL-DEVELOPED FRINGE

Anseres (true aftershaft rarely indicated)	Striges
Cathartæ	Steatornithidæ

POWDER DOWNS

Many years ago Mr. Ridgway pointed out that in *Tigrisoma* (including *Heterocnus*) the two pairs of ventral powder-down patches are connected along each side of the body. This is the case I believe in all the species. Thus there is a continuous tract of powder-downs from the root of the neck (the head of the coracoid) to the base of the tail, this tract being in *T. cabanisi* 25 cm. long.

There is a further remarkable feature of certain of the species that has apparently been heretofore overlooked. In *T. cabanisi* there is, in addition to the other tracts, a narrow patch of powder-downs 65 mm. long on each side of the median line of the upperback, bordering the inner edge of each lateral half of the dorsal tract. These two powder-down tracts are separated 15 mm. by the spinal apterium, and run 20 mm. back of the point of insertion of the last long interscapular feathers.

These interscapular powder-downs are also present but less highly developed in *T. salmoni*. In *T. lineatum (brasiliense)*, however, they are absent.¹

It should be noted that the African tiger heron, *Tigriornis leucolophi*, has normal ardeine powder-downs (three distinct, unconnected pairs) and they are gray instead of pure white as in the American species. It may also be recorded that the remarkable South American genus, *Zebrilus*, has three pairs of tracts, differing thus from the bitterns with which it agrees in having but ten tail-feathers.

The presence of powder-down patches on the upper back has been given as one of the few family characters of the boatbills (Cochleariidae). Now that this feature is found to be shared by certain true herons it becomes more than ever doubtful whether *Cochlearius*, despite its remarkable bill, merits more than subfamily rank.

¹*Tigrisoma cabanisi* has been separated (*Heterocnus* Sharpe, 1895) from the other members of the genus because of its bare throat. The remaining species also differ considerably among themselves. *T. salmoni* is unlike *T. lineatum* (the type of *Tigrisoma*) in having interscapular powder-downs, in which it agrees to a degree with *T. cabanisi*, and it differs from both these species in its smaller, thicker bill with decidedly curved culmen. The general coloration of all the American tiger herons is essentially similar and it is doubtful whether more is not lost than is gained by dismembering so natural a group. The differences in the powder-down tracts is a rather important character, however, for I do not recall any other case in which the number of tracts varies within generic limits. Surely *Heterocnus* should not be recognized unless *T. salmoni* and its near allies are also separated generically. If this is done, the name *Tigribaphe* Reichenow must apparently be used for the additional genus.

Tigribaphe was based by Reichenow (1912, Orn. Monatsber., XX, p. 61) on a supposed new species of tiger heron believed to have come from Victoria Nyanza, Africa. Chapin found by examination of the type that it was actually a South American species and this fact has been recorded by Selater in his 'Systema Avium Ethiopicarum' (1924, Pt. 1, p. 30). Both Chapin's notes and Reichenow's description indicate that the type is either *T. salmoni* or a closely allied form; Reichenow particularly mentions its somewhat *Nycticorax*-like bill.

It has doubtless been pointed out before this that the diagnostic characters of *Tigrisoma* and *Heterocnus* are transposed in the key to genera of the 'British Museum Catalogue' (Vol. XXVI, p. 59).

The tiger herons have none of the structural features of the bitterns, and in the distribution of powder-downs they are even further from the latter than are the more typical herons. The name tiger bittern, often applied to them, is therefore misleading and should be replaced by tiger heron.

I have found no reference to powder-downs in the Striges, but in the barn owl (*Tyto pratincola*) there is a well-marked patch on each side of the rump, as well as scattered downs on the interscapular and scapular regions and on the breast.

After handling in the flesh many birds of almost every family, it is my belief that powder-downs exist in an incipient or vestigial condition in many groups not credited with them, but it is not always easy to be certain in such cases whether the suspected powder-downs are truly such or not.

My notes on a specimen of an adult fruit pigeon, *Osmotreron vernans*, state that the green of the plumage was "mealy" and the underside of the slate-colored remiges whitened as though by contact with powder-downs. Examination showed numerous downy feathers on the sides of body and sides of rump that are quasi powder-downs if not typical ones, and which whiten the fingers when rubbed between them.

In two species of thick-knees, *Ædicnemus bistratus* and *Burhinus grallarius*, powder-downs were observed. In the former, these were scattered on the upper surface of the wings about the bases of the secondaries, and on the rump, particularly on its sides. In the latter species the downs were present on the wings at least.

In a female of the European bustard, *Otis tarda*, there appeared to be powder-downs on the sides of the breast and sides of the rump. Pulviplumes appear to be of rather general occurrence in the true cranes (Megalornithidæ), but never in patches. I have found them, scattered among the ordinary down, in *Megalornis* (*Grus*) *mexicanus*, *Anthropoides virgo* and *Tetrapteryx paradisea*. In *Megalornis grus* and *Mathewsia* (*Antigone*) *australasiana* they were observed on the wings. In *Monias benschi* there are, as already recorded by Mr. Bangs, definite powder-down patches. Again in the whippoorwill, *Antrostomus vociferus*, I recorded that the dark, gray semiplumes covering the breast and belly between the branches of the ventral tract, also on the rump, were whitened as though from powder-downs. The general contour plumage was not at all powdery.

Powder-downs have not heretofore been recorded in the Picaridæ (antiopelmous zygodactyl birds) but I have found them in the large woodpecker, *Mulleripicus pulverulentus*, on the sides and rump, and traces of them on the sides in *Thriponax javensis*, *Lichtensteinipicus fulvus*, and perhaps in *Ceophlæus lineatus*.

NATAL DOWN

Gadow's table is rather misleading in giving the young as bare in some Steganopodes. The nestlings of *Phalacrocorax*, *Anhinga*, and *Pelecanus* (as made clear in the text of Gadow's work), are naked when hatched but later acquire the down. In the other families the young are clothed with down nearly or quite from the first.

The young of cuckoos and turacos were long supposed to be naked and are thus marked by Gadow. It is now known that this is not altogether correct but, because Ridgway as late as 1916 ('Bds. of N. and M. Amer.') gives among the characters of this order "young gymnopædic," it seems desirable to here state what is known.

In *Cuculus* and *Chrysococcyx* there is no natal down, so far as can be judged from nestlings in juvenal plumage. In *Coccyzus*, on the other hand, the young have a hair-like natal plumage, as recorded by Herrick and shown by specimens in the American Museum collection. Shelford has recorded the peculiar white hair-like plumage of the young of *Centropus*, and this is excellently shown in a specimen of *C. neumanni* collected by Chapin. The upper surface is covered with a mantle of long, rather harsh white hairs, and there are much shorter inconspicuous hairs on the ventral tract.

Among the turacos the young of only *Turacus* and *Corythæola* are known to me and both are covered with short blackish woolly down. This has been recorded in *Corythæola* by Reichenow also ('Vögel Afrikas').

So far as known, the only birds in which the young have no downy stage are found among the Coraciiformes and Passeriformes. In these groups only the owls and the nightjars (and *Menura* ?) have densely downy young.

The young of the hummingbirds are given as gymnopædic by Gadow, Ridgway and other authorities. This is not strictly true in some species, at any rate, for in two nestlings of *Colibri* (*Petasophora*) sp. in the collection the rump feathers bear long ochraceous-buff filaments of down.

Gadow omits from his table of characters any notation regarding the young of the colies and the trogons. In the text, he states that the young colies are naked, but Chapin tells me that the nesting of *Colius nigricollis* is sparingly downy. On the other hand, in comparing the trogons with related groups Gadow credits them with downy young. Ridgway states that they are gymnopædic and this is further indicated by nestlings of *Apaloderma narina* and *Trogonurus ambiguus*, which show no down whatever adhering to the juvenal feathers.

Gadow does not indicate this character in the *Buconidæ* or *Galbulidæ*, and I therefore record the condition of the young of *Chelidoptera* (*Buconidæ*), which Mr. George K. Cherrie tells me is perfectly bare.

In the *Passeres* the young are commonly furnished with tufts of down, which as a rule is better developed in the *Clamatores* than in the *Oscines*. I have examined downy young of *Hylactidæ* (*Scytalopus*), *Furnariidæ* (*Cinclodes*), *Cotingidæ* (*Rupicola*; *Ptilochloris* so figured and described), *Tyrannidæ* (*Sayornis*, *Empidonax*, etc.), and numerous families of *Oscines*. In a few *Oscines*, however, the young appear to be entirely bare. This is the case in *Cyanocitta cristata*¹ and *Calocitta formosa* examined by me, in *Lanius ludovicianus* (two nestlings in collection), in *Gymnostinops montezuma* (recorded by L. S. Crandall), and in *Munia oryzivora* (recorded by J. P. Chapin). In none of the *Passeres* examined has there been any down on the interscapular section of the dorsal tract, nor, with the exception of *Cinclodes rivularis*, on the anterior portion of the ventral tract.

¹In his 'Plumages and Moults of the Passerine Birds of New York' Dr. J. Dwight describes the "natal down" of the blue jay as "pale mouse gray." Inspection of his specimens with Dr. Dwight indicates that this statement was probably based on an immature bird in which the downy aftershaft of a reversed feather was mistaken for a neossoptile.

Article VI.—INSECT SOUNDS

BY FRANK E. LUTZ

Probably the first definite sounds made by land-animals on this earth were made by insects. Before ever birds sang or even frogs croaked, insects had developed a chitinous covering, the segments of which, rubbing together, produced sound-waves. Whether these sound-waves were audible in the sense that there were organisms with nervous mechanisms attuned to them might be the subject of an interesting speculation. Today's crickets and katydids belong to the order Orthoptera, and orthopteroid insects were abundant in the Carboniferous. In the fields and forests of those days, or possibly earlier, was started "the poetry of earth" that "is never dead."

Judged by human ears, the best insect-musicians of today belong to rather primitive orders. The more advanced groups, such as ants, bees, flies, and butterflies, make no sounds that we can hear or else, at most, what seem to us to be nothing more than faint squeaks, buzzes, hums, or clicks. However, it is entirely probable, practically certain, that insect-sounds are not made for the purpose of being heard by human ears. Whether the insects themselves hear these sounds is the important question and one that has not been—possibly can not be—determined beyond all doubt.

In this connection it should be remembered that, in man's affairs at least, many sounds are made without intention and even contrary to desire—for examples, sneezing and snoring. No part of the success of a certain popular kind of automobile is due to the various and often loud noises emitted by the machine in action. Using an illustration more applicable to the present subject, the armor of the knights of old creaked and rattled as they moved. Their fellows were able to hear these sounds and reacted to them. A rough spot in a particular joint increased the sound made by the moving of that joint. Now, if the armor-maker purposely designed these joints to creak or if the wearer purposely creaked his armor, even if for no other motive than to tickle his pride (as has been the case with wearers of squeaking shoes), then the creaking of the joint had a significance analogous to that usually claimed for certain sounds made by insects—there was an adaptation of structure to sound-production. But, considering now the sounds made by insects, if they are merely incidental to friction between parts of their body, analogous to unintentional squeaks and rattles of knightly armor, then those sounds

have no biological significance, except as they may betray the insect to its enemies.

About fifty years ago A. H. Swinton published a book on 'Insect Variety; Its Propagation and Distribution.' It is a more or less popular presentation of the subject and contains rather good summaries of previous work, together with his deductions therefrom. His introduction to the discussion of insect-sounds contains a sentence of which the following is a part: "Reciprocating stimulatory friction of articulate parts to express emotion postulates adaptive acquisition, consequent on assumed integumental tendency under attrition to determine a smooth undulatory surface, and propagation by hereditary transmission, supposing the theory applicable." There are some that do not so suppose; others do. He then says: "The culminating points of musical perfection in a group are often indicated by other characters expressive of emotion: thus with beetles the Death Watches exhibit love and rivalry in music, and are most sensitive to touch; or the longhorns predominate in pugnacity. In Lepidoptera music is in direct relation to color, sound to beauty. Musical Orthoptera and Longicornia exhibit pugnacity. This evidently indicates parallel development of the sensorial organs."

Swinton's conclusion of the whole matter is as follows:

Should any seek to know more of the capabilities of these lowest of ear-structures than is to be gleaned from crude anatomical description, resort may be made to observation and cautious experiment. And having notated a series of insect passages, and the excitation under which they were produced, we may, if our ear be fine, even venture on a rendering into sentiment, by the formule of Mersenne, an old and sage philosopher and mathematician who flourished during the earlier portion of the sixteenth century; and the result, I think, will fully justify the assumption of a common sound-perception to our own, participated in by these humble instruments. To this end the vowels *a* and *o* must be interpreted physiologically to signify what is grand and full; the vowel *i*, that which is small and penetrating; *e*, subtlety and sorrow; *o*, is expressive of strong passion; *u*, belongs to things secret and hidden; *f*, *th*, *wh*, and the like, frequent with insects, denote sharpness or vanity; *s* and *x*, bitter things; *r*, the canine letter, violent and impetuous emotions; *m*, magnificence; *n*, things dark and obscure; and so on. Take now in illustration that pretty ballad of Percy's "O Nancy, wilt thou go with me?" and compare it in the fields with grasshopper stridulation, then it will at once strike you that while the flaunt of the first six lines will suggest the translation of many a rival challenge around, the refrain of the last couplet is nothing less than a rendering of the common pairing note. So our ballad, be it noticed, first speaks of colours and danger, russet gowns, silken sheen, a wish behind, perils keen, mishap to rue, and such-like; and we think we hear the grasshoppers, each in their own dialect, defy their mates. After this comes the tender tear, regret, scenes so gay, and wert fairest of the fair; harsh retrospect, at least, it must be allowed, represented in the grating rhythms of these saddest of little lyres when death follows fast on the reproductive gatherings. And on such pleas is it we would claim for these insect ears analogous structure and perception with our own.

These passages are not quoted for approval since, if these be the strongest "pleas," most scientists of today would deny the claim; attributing human sentiments of love, appreciation of beauty, and so on, to insects is a dubious proceeding; and, until we know more about the sounds themselves, it seems rash to explain them by such a theory as that of the inheritance of acquired characters. It may be that such characters are inherited but we need better proof than has yet come from a study of insect-sounds. These quotations do, however, represent, perhaps in somewhat exaggerated form, the views that have been held by many students of the subject.

The "music" with which "the Death Watches exhibit love and rivalry" consists in tapping the sides of their burrows. If these taps are purely incidental to the insects' movements in their burrows, they come as little within the scope of this paper as the scratching of a beetle as it scrambles among dead leaves. On the other hand, if the movements are made for the purpose of producing sound, this sound may be just as truly music to the insects as is the beating of a drum to those humans who like drum-music. If the insects communicate with one another by means of these tappings, we have a most interesting habit to investigate; but it may not be a strict case of communication by means of sound, for the other insects are in the same piece of wood and may feel the taps instead of hearing them. The fact that we hear a sound does not enter into the question. True audition might be illustrated by a chairman communicating with the members of a convention by pounding his desk with his gavel; "false audition by touch" might be illustrated by one member shaking the chair of another.

The sound caused by the vibrations of the wings as an insect flies seems to be purely incidental to the movements necessary to flight. Many insects fly noiselessly—at least, we can not hear them flying—but mosquitoes, for example, in flight make a sound that is all too familiar to us. Now, it is probable that the mosquitoes can not fly without making this sound; in other words, the sound is not made intentionally; nevertheless, it might be considered to have a biological significance if it be true that the opposite sex can hear it and that the sexes are guided to each other by its aid.

This was the idea held by Prof. A. M. Mayer in his interesting paper, 'Experiments on the Supposed Auditory Apparatus of the Mosquito' (1874, *American Naturalist*, VIII, pp. 577-592). The essential part of his paper is as follows.

I cemented a live male mosquito with shellac to a glass slide and brought to bear on various fibrils [of its antennæ] a $\frac{1}{5}$ th objective. I then sounded successively,

near the stage of the microscope, a series of tuning forks with the openings of their resonant boxes turned toward the fibrils. On my first trials with an Ut_4 fork, of 512 v. per sec., I was delighted with the results of the experiments, for I saw certain of the fibrils enter into vigorous vibration, while others remained comparatively at rest.

The table of experiments which I have given is characteristic of all of the many series which I have made. In the first column (A) I have given the notes of the forks in the French notation, which König stamps upon his forks. In the second (B) are the amplitudes of the vibrations of the end of the fibril in divisions of the micrometer scale; and in column (C) are the values of these divisions in fractions of a millimetre.

A	B	C
Ut_2	.5 div.	.0042 mm.
Ut_3	2.5	.0200
Mi_3	1.75	.0147
Sol_3	2.0	.0168
Ut_4	6.0	.0504
Mi_4	1.5	.0126
Sol_4	1.5	.0126
Bb_4	1.5	.0126
Ut_5	2.0	.0168

The superior effect of the vibrations of the Ut_4 fork on the fibril is marked, but thinking that the differences in the observed amplitudes of the vibrations might be owing to differences in the intensities of the various sounds, I repeated the experiment, but vibrated with lower intensities the forks which gave the greater amplitudes of co-vibration, and, although I observed an approach toward equality of amplitude, yet the fibre gave the maximum swings when Ut_4 was sounded, and I was persuaded that this special fibril was turned to unison with Ut_4 or to some other note within a semitone of it. The differences of amplitude given by Ut_4 and Sol_3 and Mi_4 are considerable, and the table also brings out the interesting observation that the lower (Ut_3) and the higher (Ut_5) harmonics of Ut_4 cause greater amplitudes of vibration than any intermediate notes. . . Experiments similar to those already given revealed a fibril tuned to such perfect unison with Ut_3 that it vibrated through 18 divisions of the micrometer or .15 mm., while its amplitude of vibration was only 3 div. when Ut_4 was sounded. Other fibrils responded to other notes, so that I infer from my experiments on about a dozen mosquitoes that their fibrils are tuned to sounds extending through the middle and next higher octave of the piano. . .

Some may assume from the fact of the co-vibration of these fibrils to sounds of different pitch, that the mosquito has the power of decomposing the sensation of a composite sound into its simple components, as is done by the higher vertebrates; but I do not hold this view, but believe that the range of co-vibration of the fibrils of the mosquito is to enable it to apprehend the varying pitch of the sounds of the female. In other words, the want of definite and fixed pitch to the female's song demands for the receiving apparatus of her sounds a corresponding range of co-vibration, so that instead of indicating a high order of auditory development it is really the lowest, except in its power of determining the direction of a sonorous centre, in which respect it surpasses by far our own ear.

Professor Mayer gave no data concerning the pitch of the female's sound or its variability. The intensity of such a sound, especially at a

distance great enough to make it a desirable factor in guiding the male, is so slight that the sound from a tuning fork on a resonant box placed near and turned toward the antenna would be like that of an artillery battle in comparison. I have watched under a high-power microscope a male mosquito's antenna when a number of female mosquitoes were flying in the vicinity and could see no motion of the "fibrils," but perhaps the microscope was not sufficiently powerful and, at any rate, we do not know how slight a variation the male can feel.

It would be interesting to know whether male mosquitoes are really guided to the females by sound, regardless of the way in which that sound is perceived. To test this I bred a large number of mosquitoes and separated the sexes before they had a chance to mate. After they had been kept for some time so that they were probably sexually mature, each sex was put in a wide-mouthed jar, the opening being covered with netting. The mouth of the jar containing the males was then brought close to that containing the females but there was no noticeable crowding of the males on the netting that separated the sexes, although the females were flying about. Thinking that the failure of the males to go toward the females might be due to the fact that the males were confined, and remembering that certain kinds of male moths are attracted great distances to a confined female, I put a jar of females near a breeding-place of mosquitoes and watched at night to see if any males came. Furthermore, to be certain that there were males in the vicinity, I released at the mouth of the jar of females many males that had not yet mated. Although the females were flying about in their jar and producing what sounded to me like their characteristic shrill note, no males came to the netting that confined the females.

This was disappointing, and doubly so because it proved nothing beyond the fact that the males did not come to those confined females. In the case of the moths, the males are supposed to locate the females by odor and, if male mosquitoes had been attracted to the jar containing the females, it would have been necessary for us to consider the possibility that odor was the guiding factor. As it was, the only thing left was to wonder how male mosquitoes do find their mates. Incidentally, it may be said that none of the experiments believed to have demonstrated that odor is the guiding factor in the case of moths have absolutely ruled out sound, and male moths have antennæ, quite as plumose, apparently as well fitted to receive sounds, as those of male mosquitoes.

Certain insects that make a buzzing, humming noise when they fly make a much shriller sound when they are caught and their wings are

held. Classic examples of this are bees and syrphid flies. Since some of these syrphid flies resemble bees in appearance (but, of course, do not sting) they are said to "mimic" bees and the shrill noise made by them when they are caught is believed to add to the deception and to persuade the captor to release them under the fear of getting stung. This implies that the enemy to be deceived can, like man, hear these sounds but, unlike most men, can not distinguish between the note of the fly and that of the bee. Probably the chief enemies of these flies are spiders and certainly the flies sound the note quite vigorously while the spiders are winding them up in silk, but just as certainly the spiders keep on winding and the flies profit nothing by the noise they make. As this shrill note is not sounded until the fly is caught, toads and the like would not hear it before the fly was inside of them and then feeling would probably give more certain information than sound as to whether the captive was a fly or a bee. Birds would be more apt to be tricked before they had swallowed, but certain fly-catchers make a specialty of catching bees and for them, at least, a fly making a noise like a bee would not be an object of terror. On the whole, if these flies do successfully mimic bees, they must do so on the strength of their looks or their flight-hum, not by the shrill sound they make when their wings are stopped from vibrating naturally.

The history of investigations concerning the production of this shrill note is very interesting. As far as we know, most insect sounds are not vocal; that is, they are not produced by lungs and larynx. Insects have no lungs such as vertebrates possess but air is conducted to various parts of the body through a system of tubes, the tracheæ. These tracheæ open to the outside through a series of holes, the spiracles. Landois, in a justly classic paper (1866, *Zeitschrift für wissenschaft. Zoologie*, XVII), described a number of experiments, including cutting off not only the wings but other parts of flies. He dissected the tracheæ and gave beautiful drawings of the spiracular membrane which he asserted was set into vibration by the insect's forced breathing, thus producing the sound. Other work confirmed this idea, and comparative anatomy showed that certain flies, such as Stratiomyidæ, that do not produce this shrill note have only feebly developed spiracular structures. No wonder, then, that Pember-ton showed some timidity in announcing (1911, *Psyche*, XVIII, pp. 114 to 118) the results of his work. He said, in part:

Despite the weight of testimony which seems to favor the theory of the spiracular voice, I cannot avoid the conclusion, from these observations of my own, that there has been some curious mistake about it all. My experiments with several species of Syrphidæ (*Eristalis tenax* in particular), the house fly, honey bee and the bumble bee,

show that these insects do not produce audible sounds by vibration of any portion of their spiracles or tracheæ, but that all sounds of the nature of buzzing produced by them are made solely by the wings, either by their vibration in the air or by striking the wing bases against the body wall.

In all the experiments I have kept constantly in mind Landois's theory and all my experiments have been performed in an attempt to verify it. However, not in a single instance have the results pointed in any way toward Landois's conclusions.

His experiments included pulling out, not merely cutting off, the wings; holding the wing-bases; destroying the spiracles with a needle; examining the spiracles while the sound was being made to see if there were any motions; and so on. He added:

The above experiments were carefully repeated several times with the same results in every case. They seem to prove quite conclusively that the supposed sound of the spiracles is merely a buzzing of the wing bases or a striking of them against a portion of the body-wall adjoining them. The well-adapted character of the spiracles for the production of sound if air could be very violently forced through them, combined with the confusing fact that the same pitch of sound is produced both with the wings cut off and intact, might easily lead one to conclude that the sounds were produced by some other organ than the wings.

The question may well be asked, "Why are the spiracles so modified and complex as Landois considers them?" It must be taken into consideration that the spiracles are comparatively large openings to a very delicate and vital tracheal system, which should be safely guarded at its openings against the entrance of dust particles. In most cases they are protected by a dense growth of hairs but often are not, as for example in the honey bee. The thoracic spiracles of the honey bee are poorly protected externally but within the opening this folded membranous curtain, or so-called vocal membrane, acts undoubtedly as a screen against the entrance of dust, etc.

Pemberton's conclusions received support from Aubin (1914, Journ. Royal Microscopical Society), who offers the following suggestions as to the reception and purpose of this sound.

It is evident that the organs of phonation of *Eristalis* described above are of a higher order than the stridulating organs of Coleoptera and Orthoptera and a little consideration will tend to the belief that it is not impossible that they fulfil the dual function of emitting and receiving sound. According to the laws of acoustics a stretched membrane will vibrate under the influence of external notes which are approximately in unison with the note it can itself emit; it is therefore not unreasonable to infer that the resonant areas will respond to the buzz of other individuals and thus form one of the elements of an auditory apparatus.

If it be further borne in mind that, in *Eristalis* and perhaps in other genera the note is susceptible of a somewhat syren-like modulation, it is not inconceivable that the sound produced may be the means of transmitting a variety of indications to the similarly attuned organs of other individuals.

The precise part played by buzzing in the life of the individual is somewhat obscure, but the fact that these organs are equally developed and equally efficient in both sexes of *Eristalis* would seem to indicate some function other than or in addition to a sexual one.

Such observations as I have been able to make on this point are quite insufficient to justify any conclusion, but, so far as they go they indicate that the buzz serves, *inter alia*, as a warning note to aggressors.

These observations are as follows:

(1) Several of the hover-flies, if held lightly in the fingers, will buzz for comparatively long periods and many specimens of *Eristalis*, if held by the legs, will alternate, almost without intermission, between buzzing and attempting to fly.

(2) Most Diptera, when entangled in a spider's web, will buzz at intervals. If quiescent the captive will almost invariably buzz if the spider, in order to ascertain the nature of its captive, touches it with an investigating claw.

(3) If a cage containing *Eristalis* be taken into a partially darkened room, they will cease flying and either remain stationary or crawl about slowly. Under such conditions, should one individual touch another, the one so touched will emit a short, sharp buzz which is sometimes responded to by others in the cage.

(4) A captive, under the microscope, can usually be made to buzz by touching it with a needle, more especially on the abdomen or wing shoulder.

The "resonant areas" to which reference is made are small parts of the wing-membrane and, as we know of no nervous tissue in their vicinity, it may seem to some quite "unreasonable to infer" that these nerveless areas are sound receptors. Since almost anything is conceivable, "it is not inconceivable that the sound produced may be the means of transmitting" ideas but, as Aubin said, his observations "on this point are quite insufficient to justify any conclusion." His observations as to the warning value of this sound are certainly not conclusive. About all we can say is that, when *Eristalis* vibrates its wings without flying, the bases of the wings hit against the body and make a noise.

Although the spiracular "voice" of Diptera seems to be disposed of, as far as past work is concerned, Duncan has just published a note (1924, Pan-Pacific Entomologist, pp. 42 and 43) concerning a grasshopper, *Tæniopoda picticornis*, that apparently does produce a spiracular sound, faint though it be and apparently inconsequential. He says:

The sound is of about the intensity of that resulting when two pieces of writing paper are rubbed together and is produced by the spewing out through the second thoracic spiracles of a small quantity of watery liquid at each exhalation. Many tiny bubbles are formed each time the sound is produced. These vary a great deal in number, being at times hardly noticeable and again forming a mass a good three-sixteenths of an inch in diameter. Immediately after being formed the bubbles disappear, leaving an area around the spiracles that is wet for a second or so.

There are no grounds for doubt as to the mechanism by means of which the sound is produced, for in addition to the fact that it is obviously synchronous with the exhalation of air from the tracheæ and the formation of the bubbles noted, it is exactly the sort of sound that one associates with the spewing of a mixture of air and liquid through a small hole, its intensity varies according to the amount of bubbles produced, and the sound ceases entirely when the production of bubbles ceases, as it does shortly (apparently due to a using up of the supply of liquid available) if the

hoppers be continuously stimulated for a time. Moreover, the sound may be produced by nymphs as well as adults, thus eliminating the wings as stridulatory organs, and it may be produced even though the legs of the hoppers be held perfectly still. The sound is apparently under full control of the insects and, as far as I could learn, is produced only when they are disturbed.

In other words, the grasshoppers, when disturbed, contract their body, forcing a little air out of the tracheæ and, if there be any fluid present, bubbles are blown and broken, incidentally making a faint sound. Harvey (1907, *Canadian Entomologist*, XXXIX, p. 18) has reported that a water-bug, *Pedinocoris macronyx*, makes a "soft chirping noise" by means of its ventral spiracles as it poised just at the surface of the water.

One insect sound that long enjoyed a very interesting explanation of its purpose is the "drumming" or "trumpeting" of bumblebees. Goedart started the idea in the Seventeenth Century with his essay 'De Insectis, in Methodum Redactus; cum Notularum Additione,' in which he says that every morning about 7:00 A.M. a member of the colony goes to the top of the nest and beats his wings to rouse the others and let them know that it is time to get to work. Eight years later the great Reaumur denied the story but, as his only evidence was that he had not observed such actions, his denial carried only the weight of his authority. A French abbé, de Pluche, confirmed Goedart except to say that the rising signal is given at 7:30 instead of 7:00. Something more than a hundred years later Hoffer moved the time of the rising signal ahead to about 3:00 A.M. and said that it was kept up for about an hour. To give the remainder of this history I quote extracts from Plath's paper (1923, *Psyche*, XXX, pp. 146 to 154) on this subject.

Hoffer's (1882-83) confirmation again brought Goedart's "trumpeter" story into good repute among biologists for a period of more than twenty years. With apparently the single exception of Perez (1889), it was accepted—in most cases after personal verification—by Fritsch (cf. Hoffer, 1882-83, p. 25), Kristof (1883), Harter (1890), Sharp (1899), Marshall (1902), and Bengtsson (1903). Perez (p. 117), while not in the least doubting the general correctness of Hoffer's (1882-83) observations, rejected the latter's interpretation by pointing out (1) that there is little sense in having a "trumpeter" unless he be the first one to rise, and (2) that the sound produced by the "trumpeter" is of no use whatever, as far as rousing the colony is concerned, since (according to Perez) bumblebees, like honey bees and ants, are completely deaf. Perez (1889) then offers his own explanation. After expressing the opinion that the bumblebee "trumpeter" fulfills no social function, and that the "trumpeting" is probably done for his own benefit, Perez (p. 117) suggests that the "trumpeters" in bumblebee colonies, like the so-called ventilators among honeybees, are newly-hatched individuals which are training their wing muscles for the long flights which they will soon make. However, as we have already seen, Perez' (1889)

theory, although more plausible than that of Goedart (1685), seems to have made little or no impression upon contemporary biologists.

Fourteen years after the publication of this theory, a third interpretation was offered by the well-known German bee student von Buttel-Reepen (1903, 1907). Unlike Perez (1889), this author suggested that the bumblebee "trumpeter" has the same social function as the ventilators in the honeybee colony, namely, to reduce the temperature, or to expel moisture or bad odors from the nest. Similar conclusions were reached by the Norwegian biologist Lie-Pettersen (1906). This new interpretation was accepted—in some cases after extensive experimentation—by Stierlin (1906), Wagner (1907), Gundersmann (1908), Lindhard (1912), and Sladen (1912).

However, within the last decade, Goedart's (1685) "trumpeter" story has found another adherent in Bachmann (1915, 1916). What is more, Bachmann (1915) has discovered that the bumblebee "trumpeter," in addition to rousing the members of the colony in the morning, also attends to the "curfew" in the evening.

Plath gives the results of his own experiments on about sixty colonies of various species of bumble-bees and concludes as follows:

1. The so-called trumpeters in bumblebee colonies are bees which are engaged in ventilating the nest.
2. This ventilation is brought about by a rapid vibration of the wings and may take place at any time during the day or night.
3. Species which nest on the surface of the ground likewise make use of this method of ventilating their nests.
4. Ventilation by fanning is also resorted to by small bumblebee colonies.
5. Perez' theory, according to which the so-called trumpeters in bumblebee colonies are newly emerged individuals which are exercising their wing muscles, is not founded upon facts.

And, so, one more insect sound for which a very definite purpose had been assigned sinks into the category of a noise that is purely incidental to a movement that was not intended to make a noise.

The "voices" of honey-bees have long been classic. Many and various have been the descriptions and interpretations. Mrs. Comstock, in her 'How to Keep Bees,' mentioned only the queen, which she did as follows.

The belligerent attitude of the queens toward each other seems to have been so strong an emotion that a voice has been developed to express it, and is eloquent with rage and fear. This note must be heard to be understood; as nearly as I am able to spell it, it is "tse-ep, tse-e-e-ep, tse-e-ep, tsep, tsp, tsp, ts," in a sort of diminuendo. She makes the noise when she discovers another queen cell; if there is within this cell a full-fledged queen, she pipes back, but it sounds quite differently and the note is more like "quock, quock." This piping of queens is especially evident before an after-swarm is to issue. The queen will also pipe when bees gather about her and try to ball her, which is often the fate of a new queen introduced into a colony not ready to receive her. In this case the note is one of righteous anger at the indignity to her royal person. She makes this piping with some vocal instrument, not well understood. Her wings vibrate tremulously while she is piping, but she can pipe quite vociferously after her wings have been entirely cut off.

We learned from the discussion of flies that cutting off the wings is not sufficient because the bases of the wings are still there to hit against the thorax.

Cheshire in 'Bees and Bee-keeping,' discussed the bee's sense of hearing and quite properly objected to drawing sweeping conclusions from the negative results of certain experiments. He said.

Sir J. Lubbock has commonly been regarded as asserting the total deafness of bees; but, in a correspondence of some years since, the distinguished investigator assured me his position was negative, as he merely failed to get evidence of bees hearing. Sir J. Lubbock's experiments I cannot but regard as most inconclusive, since tuning-forks, whistles, and violins, emit no sounds to which any instinct of these creatures could respond. Should some alien watch humanity during a thunderstorm, he might quite similarly decide that thunder was to us inaudible. Clap might follow clap without securing any external sign of recognition; yet let a little child with tiny voice but shriek for help, and all would at once be awakened to activity. So with the bee; sounds appealing to its instincts meet with immediate response, while others evoke no wasted emotion. In practical matters, the hearing of bees is not only often obvious, but must be taken into account—*e.g.*, when a swarm is about to be transferred to its permanent abode from its temporary one, many will stick to the sides of the latter after the bulk have been thrown out, and these, by their buzz, will distract those that are running in at the new hive door. The removal of the stragglers to a distance will end the disturbance, which will be renewed if they be returned to their former position. Some years since I was present in a tent where an expert had driven five or six stocks, and nearly a pint of lost bees had collected for mutual comfort on a piece of damp canvas, at the bottom of the tent pole, against which the last skep was made to lean, as it was stood, quite late in the evening, on a table for operation. No sooner did the bees in this skep set up the wellknown roar, than those on the canvas, so still hitherto, faced upwards, unhesitatingly ascending the pole, and setting on the outside of the roof of the receiving skep. This circumstance I remember as affording, to all who witness it, conclusive evidence of hearing.

In the progress of the present we moderns have, perhaps, too confidently condemned *all* the past. The conflict of the key and warming-pan of old swarming days has called forth some good-humoured but possibly not always philosophical, banter, for I confess I think, that in its day, it had its value. Piping of queens, whatever be its cause, seems to point to a sense of hearing, for it appears to be a sound made for an object, and not the result of some necessary movement.

Even Forel, that confirmed sceptic concerning the ability of insects to hear sounds as such, said in 'The Senses of Insects':

The [strange] queen escapes but is pursued. Then in her terror, she utters "cries of fright" which disturb the whole hive. The disturbance of the hive is, indeed, not produced when the queen is caged and does not cry. Von Buttle concludes therefrom that the workers hear the queen's frightened cries.

I confess that the judicious remarks and the experience of an observer so excellent as von Buttel Reepen make me seriously doubt on the question of hearing in insects. Nevertheless, it fails to convert me on a fundamental point: where is its organ, if it exists as a special sense, for special energy? We know and prove without

difficulty the organs of other senses. Why not that of hearing? So long as its seat and the deafness consecutive to its extirpation have not been demonstrated there remains a possibility that even von Buttel cannot exclude, that of the "false audition by touch" of Duges. I have shown elsewhere how insects, so light and so small, are easily impressed in their tactile organs by the least vibrations of the atmosphere and of the bodies which sustain them. But precisely those of the experiments of von Buttel which peremptorily exclude sight, that is to say those which are passed in the darkness of the hive or across its contents, in no way exclude the tactile perception of vibrations. And those which seem to indicate an audition at a distance in the open air do not exclude vision. The differences of the tones emitted by bees, differences which we perceive by our hearing, might very well be perceived by them as differences of tactile vibrations, according to their amplitude, as we ourselves perceive very deep sonorous vibrations by touch, and not only by hearing. There is here a very hard question, which must be put. But whether we are dealing with hearing properly speaking or not, the fact that bees communicate their impressions and their emotions has been victoriously demonstrated by von Buttel against Bethe, and confirms what I have observed in ants.

McIndoo (1922, *Journ. Comp. Neurology*, XXXIV) confirmed the idea derived from recent studies of flies that the shrill "squealing" noise of bees is due to the striking of the wing-bases against the thorax. He added:

Besides the buzzing and squealing noises made by bees, the writer often heard a crackling sound while observing these insects flying around an alighting-board. He could not detect how this sound is made, but imagined it produced by the wings striking together accidentally.

All attempts, except one, trying to get bees to respond to the squealing of other bees failed. Or at least the bees exhibited no reactions which could be attributed as signs of hearing. Nevertheless, one squealing bee was held in a hidden position a few inches from an alighting-board; at once one of the many workers on this board seemed to take notice and flew to the screen behind which the squealing bee was hidden, and then it came immediately to the squealing bee, which it began to examine by running around it and smoothing its hair.

A queen bee, resting on a comb with workers surrounding her, when squeezed, squealed and the near-by workers became excited. Such experiments really do not mean much, because too many interfering factors cannot be eliminated. The original plan of the writer was to carry on experiments in which he hoped to be able to classify and to record on phonograph records the various sounds heard in a hive of bees. If this were possible, he intended to reproduce these sounds and then to determine whether or not bees respond to them.

If bees have as acute a sense of smell as many students believe them to have, neither hearing nor the "false audition of touch" are necessary to explain many of the reported observations on bees. At least, the possibility of odor being concerned has usually not been excluded, although it would seem to be so in the case of a young queen, still enclosed in wax, hearing the "tse-ep" of the reigning queen and answering "quock." This dialogue needs further investigation. Sladen and others

have discussed certain scent-glands on the abdomen of bees and suggested that odors perceptible to bees are blown out from these glands by the vibration of the wings, which vibration affects human auditory organs. Even though all this be true, one would scarcely expect many different ideas to be expressed by odor. Excitement might cause excessive activity of a gland in a bee as it does of sweat glands in man and this scent might excite other bees but, if we must admit many different emotions, it becomes difficult to imagine a sufficient variety of odors and sufficient control over them to meet the needs.

Probably the emotions and the means of communicating them have been more studied in ants than in any other group of insects. Most of the essential data are given in Wheeler's 'Ants,' from which the following quotations, if not otherwise acknowledged, are taken.

Especially in the Ponerinæ and Myrmicinæ, the abdomen bears on the dorsal surface of the base of the gaster a series of fine, file-like ridges. A segment in front of this overlaps it and has a sharp edge that scrapes the file when the abdomen moves in certain ways, producing a faint sound of high pitch. "The file is, in all probability, merely a local specialization of the fine, polygonal elevations or asperities which cover the adjacent portions of the segment and are so characteristic of the chitinous investment of many parts of the body." An Australian ant has coarse ridges in one part of the file and fine ridges in another, and Sharp suggested that it may have two notes in its repertoire but apparently no one has heard it squeak. "Janet, in his studies of *Myrmica rubra*, calls attention to the fact that there are accumulations of chitinous asperities at various widely separated regions of the ant's body, especially on articulations which might, by their movements, produce sounds. But the true stridulatory organs he finds to be situated where they were seen by Landois and Sharp, i.e., at the base of the first gastric segment, and also on the corresponding part of the postpetiole."

Suggested auditory organs in ants are the "chordotonal" and the Johnstonian. The former has been considered to be the more important and the latter may be only a variety of it but apparently proof that either receives sound is lacking. A necessity of finding some auditory organ is felt and "the chordotonal organs are supposed to be auditory in function because they are most elaborately developed in the stridulating Orthoptera (crickets and katydid), and because their structure would seem to be adapted to responding like the chords of a musical instrument to delicate vibrations." "These structures, which are present in a great many insects, even in the larval stages, are typical compact, spindle-

shaped bundles of sensillæ, each consisting of a chitin-secreting gland and a nerve cell. These cells are arranged in a series at an angle to the integument and are stretched, like a tendon, across a cavity between opposite points in the cuticle, or between a point in the cuticle and some internal organ. . . Eight pairs of chordotonal organs have been seen in the ant's body, but it is not impossible, as Janet suggests, that others exist, for such minute and recondite objects are very easily overlooked even in well-prepared sections." If every insect that possesses "chordotonal organs" can hear, most insects can.

One of Lubbock's many ingenious experiments was designed "to ascertain whether ants have the power of summoning one another by sound." On a board where a colony of *Lasius flavus* was usually fed he placed some small pillars of wood about an inch and a half high and honey was placed on the top of one of them. Ants wandered all around hunting for food. Ants that had fed on the honey were captured before they descended but three were allowed to feed on top of the pillar at a time. Lubbock felt that "if they could summon their friends by sound, there ought soon to be many ants at the honey" but the other ants did not come and Lubbock concluded that "it seems obvious therefore that in these cases no communication was transmitted by sound." He might have added "or in any other way or, if there was, no attention was paid to the communication." In other words, the experiment is not crucial and, furthermore, *Lasius* belongs to the Camponotinæ, a group that is not noted for its stridulations. However, this same *Lasius flavus* has "a remarkable arrangement, which at once reminds us of that which occurs in *Gryllus* and other Orthoptera. In the femur it [a trachea] has a diameter of about $\frac{1}{3000}$ of an inch; as soon, however, as it enters the tibiæ, it swells to a diameter of about $\frac{1}{800}$ of an inch, then contracts again to $\frac{1}{5000}$. Moreover, as in *Gryllus*, so also in *Formica*, a small branch rises from the upper sac, runs almost straight down the tibiæ, and falls again into the main trachea just above the lower sac." The argument usually used in such a case is that this structure is probably an ear and therefore *flavus* certainly makes sounds to be heard by these ears. Lubbock continued as follows.

Again, Professor Tyndall was good enough to arrange for me one of his sensitive flames; but I could not perceive that it responded in any way to my ants. The experiment was not, however, very satisfactory, as I was not able to try the flame with a very active nest. Professor Bell most kindly set up for me an extremely sensitive microphone; it was attached to the underside of one of my nests; and though we could distinctly hear the ants walking about, we could not distinguish any other sound.

It is, however, far from improbable that ants may produce sounds entirely beyond our range of hearing. Indeed, it is not impossible that insects may possess senses, or sensations, of which we can no more form an idea than we should have been able to conceive red or green if the human race had been blind. The human ear is sensitive to vibrations reaching at the outside to 38,000 in a second. The sensation of red is produced when 470 millions of millions of vibrations enter the eye in a similar time; but between these two numbers, vibrations produce on us only the sensation of heat; we have no special organs of sense adapted to them. There is, however, no reason in the nature of things why this should be the case with other animals; and the problematical organs possessed by many of the lower forms may have relation to sensations which we do not perceive. If any apparatus could be devised by which the number of vibrations produced by any given cause could be lowered so as to be brought within the range of our ears, it is probable that the result would be most interesting.

The befuddled state of scientific opinion on the matter of sounds and sound-reception by these much-studied insects is shown by the following portion of Wheeler's concluding paragraph.

Huber (1910) and Forel (1874) deny that ants hear sounds, and the latter, while admitting that they respond easily to grosser mechanical shocks, failed to obtain any response to sounds of a very high pitch. Lubbock (1881), on the other hand, believed that they react to such sounds, but he failed to obtain any experimental evidence for his view. Parker and Miss Fielde (1904) failed to observe any reactions to "aerial sound waves from a piano, violin and Galton whistle, which collectively gave a range of from 27 to 60,000 vibrations per second." The insects reacted, however, to vibrations reaching them through the soil and other solids. These vibrations were received through the legs, as they were perceived even when the antennæ, head, abdomen and any one or two pairs of legs were removed. In contradiction to this view and that of Forel, several authors have recently maintained that ants do perceive aerial vibrations. That this is the case has been stated by Weld (1899) for *Cremastogaster lineolata*, *Lasius americanus* and *Aphænogaster* sp., and by Metcalf (1900) for "a small black ant." Wasmann (1891, 1899) has recorded similar, rather inconclusive observations. I have also virtually expressed myself in favor of such a view in one of my papers (1903), in a passage which has been overlooked or misunderstood by some recent students of this subject, and may therefore be repeated in this place: "Stridulation, at least among the Myrmicinæ, Ponerinæ and Dorylinæ, is an important means of communication, which Bethe has completely ignored and even Forel and other myrmecologists have failed to appreciate. It readily explains the rapid congregation of ants (Myrmicinæ) on any particle of food which one of their number may have found, for the excitement of finding food almost invariably causes an ant to stridulate and thus attract other ants in the vicinity. It also explains the rapid spread of a desire to defend the colony when the nest is disturbed. This is especially noticeable in species of *Pheidole*, *Myrmica* and *Pogonomyrmex*. It is the secret of being able in a short time to catch ants like *P. molefaciens* in great numbers by simply burying a wide-mouthed bottle up to its neck in the mound of the nest. An ant approaches and falls into the bottle. It endeavors to get out, and failing, begins to stridulate. This at once attracts other ants which hurry over the rim and forthwith swell the stridulatory chorus till it is audible even to the human ear. More ants are attracted and soon the

bottle is filled. [May not the real attraction have been odor or may there have been no attraction at all, the hurrying ants, distracted by the damage to their nest falling into the bottle by simple accident?] If it be corked and shaken for the purpose of still further exciting its contents, and then held over another *Pogonomyrmex* colony whose members are peacefully sauntering about on the dome of the nest, the wildest excitement will suddenly prevail, as if there had been a call to arms or to dinner. [Of course, odor was excluded here if the cork was left in, as it probably was not.] Even more remarkable is the stridulation in a colony of *Atta fervens* (= *texana*), the Texan leaf-cutting ant. Here the different ants, from the huge females through the males, large soldiers and diminishing casts of workers to the tiny minims, present a sliding scale audibility. The rasping stridulation of the queen can be heard when the insect is held a foot or more from the ear. To be audible the male and soldier must be held somewhat closer, the largest workers still closer, whereas the smallest workers and minims, though stridulating, as may be seen from the movements of the gaster on the postpetiole, are quite inaudible to the human ear. It is not at all improbable that all this differentiation in pitch [volume?], correlated as it is with a differentiation in the size and functions of the various members of the colony, is a very important factor in the cooperation of these insects and of ants in general. The contact-odor sense, important as it undoubtedly is, must obviously have its limitations in the dark, subterranean cavities in which the ants spend so much of their time, especially when the nests are very extensive like those of *Atta*. Under such conditions stridulation and hearing must be of great service in maintaining the integrity of the colony and of its excavations." If the view of Miss Fielde and Parker be accepted, we must suppose that the *Pogonomyrmex*, in the experiment above described, were thrown into agitation by vibrations passing from the bottle of stridulating ants through my body to the soil of the nest. It seems to me much more probable that the ants perceived the stridulation directly as aerial vibrations. More numerous experiments, however, have been recently performed by Turner (1907). Although he worked only with Camponotine ants (*Formica fusca* and *F. sanguinea*), which are not known to stridulate, he found that they responded to vibrations as low as 256 and as high as 4,138 per second. "The responses, in the form of zigzag movements, were usually slight for pitches higher than 3,000 vibrations per second and sometimes slight for other pitches; but, to most pitches under 3,000 vibrations per second, the ants usually responded in a pronounced manner, usually darting about as though much excited." Turner believes that he took sufficient precautions, by resting the nest on cotton and felt, to exclude the transfer to the ants of vibrations through the floor, table and walls of the nest. It is, however, extremely difficult to prove that such vibrations were excluded, and for this reason we cannot, with the data at hand, reject the statements of Miss Fielde and Parker. As these authors say: "It has long been recognized by physiologists, if not by the scientific public, that touch and hearing in the vertebrates are very closely related. The apparent separateness of these senses in us is due to the fact that the air waves by which our senses are usually stimulated are too slight to affect our organs of touch. If, however, we transfer our experiments to water, we at once meet with a medium in which, as has long been known, vibrations can be both heard and felt. In dealing with a like question among the lower animals it therefore seems to us misleading to attempt to distinguish touch from hearing, and we shall be more within the bounds of accuracy if we discuss the question from the standpoint of mechanical stimulation rather than attempt to set up questionable distinctions based upon human sensations."

I regret that no colony of *Pogonomyrmex* is available to me at the present time. The largest ant-nests in this vicinity are those of *Formica exsectoides* and, as this species not only does not make sounds audible to man but belongs to a group that is practically silent as far as unaided human ears can tell, work on it can not be set forth as comparable with Wheeler's experiments on *Pogonomyrmex*. However, I pushed a test-tube into such a nest until the open mouth of the tube was flush with the surface of the nest. Ants came rushing out and crowded around the point of disturbance; one ant fell into the tube, then another and another until there was quite a collection entrapped. Then the excitement subsided and only occasionally did an ant come to the tube and join her imprisoned comrades. Next I pushed into the nest four test-tubes differing as follows: two were covered with coarse netting, one containing ten live ants and the other empty; the remaining two were covered with thin rubber (not stretched but with the edges fastened tightly against the tube), one containing ten live ants and the other empty. The rubber certainly prevented any ant-odor from escaping. Of course, the rubber might also confine sounds inaudible to us but audible to ants, if such sounds were made. However, the rubber was thin and not under tension; also, this same arrangement did not appreciably alter either the volume or the character of faint stridulations made by other insects—for example, the longicorn beetle *Tetraopes tetraophthalmus*. A much more uncertain thing about the experiment was interpreting the actions of the ants. They came rushing out of the nest as before and ran pell-mell over the mouths of all the tubes. If the mouths of the tubes had not been covered, many would have been trapped. The difficulty was that the ants moved so rapidly and each looked so much like the others that I could not get any trustworthy statistics concerning the number of different visits made to each tube but my impression (strengthened by repetitions of the experiment) was that, if any tube received more attention than would be given to any foreign object pushed into the nest, it was the tube covered with coarse netting and containing living ants. This is what would be expected if one thinks that ants are attracted by the odor of excited imprisoned comrades and such expectation may have been the chief basis of my impression.

The stridulatory organs of beetles have been very well reviewed by Gahan (1900). Not as a conclusion to be drawn from his study but merely as a statement of fact, he said that "wherever any part of the external surface of the body is subjected to the friction of an adjoining part by the movements of the insect, there, in some species or another, these organs

are almost sure to be found. They do not remain constant in position even among the different genera of the same family, yet they sometimes appear unexpectedly having almost identically the same position and structure in one genus that they have in a genus of some totally different family." Many of these stridulations are very distinctly audible to man—for example, those of certain long-horned beetles when the beetles are held and make all sorts of motions in an effort to escape. It is also said that some beetles stridulate while mating. Then, too there is the sound made by the "June bugs" and others during flight—Shakespeare's "shard-borne beetle with his drowsey hum." It is what Riley had in mind when he said:

The beetle booms adown the glooms
And bumps along the dusk

but the beetle probably had no more intention of booming than it had of bumping. At least none has been proven, neither has the existence of special sound-receiving organs in any kind of beetle, unless "chordotonal organs" be such.

Although the sound-producing organs of most beetles are very simple in structure, the wood-boring larvæ of certain Passalidæ have extreme modifications for this purpose. Sharp (Cambridge Natural History, VI, p. 192) figures one of these from Borneo. He says:

The larvæ are very interesting, from the fact that they appear to have only four legs. This arises from the posterior pair being present only as very short processes, the function of which is to scrape striated areas on the preceding pair of legs and so produce sound. In the species figured this short leg is a paw-like structure, bearing several hard digits; but in other species it is more simple, and without the digits. The perfect insect has no sound-producing organs, and it is very remarkable therefore to find the larvæ provided with highly-developed stridulatory structures. No auditory organ is known, unless the peculiar spiracles be such.

Sharp gives no explanation of the reason for the existence of this power to produce sound. As they are larvæ, it can not be a sexual call. As they are buried deep in decaying wood, it is probably not for the purpose of frightening enemies, although a sufficiently great imagination might conceive it to be so. It has even been suggested that the sound is a warning to brothers and sisters in the same mass of wood that the particular spot in which they are feeding is preempted.

The various clickings and other faint sounds made by certain butterflies and moths may be passed at present. They do not differ materially in method of production and known biological significance from those already mentioned. In some cases "ears" have been described, being situated on the abdomen, and, as was pointed out above, the

antennæ of moths seem to be structurally as well fitted to perceive sound as do the antennæ of mosquitoes. A fairly complete bibliography concerning the auditory powers of Lepidoptera is given by Turner and Schwarz (1914, Biol. Bull., XXVII, p. 291). The following quotations, the first from the paper just mentioned and the others from a paper by Turner in the same volume, p. 332, are of interest in connection with the ability of insects to hear sounds audible to us although they themselves do not make such sounds.

We do not consider the failure of these moths to respond to certain sounds of low pitch a proof that they do not hear such sounds; indeed, we are inclined to believe that these creatures respond only to such sounds as have a life significance. Three things render this last assumption probable: (1) The fact that *C. unijuga*, which at first did not respond to whistling, did so readily after once a blast of air had been allowed to strike her body simultaneously with the sounding of the whistle; (2) that most of the natural enemies of these moths produce high pitched sounds and trains, and brass bands and other producers of low pitched or coarse sounds do not directly affect the survival of these moths; and (3) by carefully conducted field experiments, we were able to induce three specimens of *C. neogama* to respond to sounds to which the species does not usually react.

It seems certain that all four of the species of giant silk-worm moths investigated can hear. Three of the species respond readily to a large range of sounds. The third, *Telea polyphemus*, normally does not respond to sounds; unless remaining as immobile as possible be considered a response. By experimentally causing the moth to associate some disagreeable experience with certain sounds, it can be induced to respond to those sounds.

There is much evidence that the responses of moths to stimuli are expressions of emotion. The fact that an insect does not respond to a sound is no sign that it does not hear it. The response depends upon whether or no the sound has a life significance.

Leaving the insects having complete metamorphosis and considering the rather primitive order Orthoptera, we find among the saltatorial groups an abundance of species having highly developed organs for producing and possibly for receiving sounds. Sharp noted that the musical powers are especially characteristic of the male sex and stated that "there is evidence that these powers are of great importance to the creatures, though in what way is far from clear." He does not say what this evidence is but, since the way in which these powers are important is far from clear, the fact of their existence is probably what he had in mind as the evidence of their great importance. At any rate, this is a characteristic neo-Darwinian argument.

One of my early ventures into scientific discussion was inspired by a translation of a paper by Portchinsky (1886) and had the following to say concerning the short-horned grasshoppers.

Considering the Orthoptera, he [Portchinsky] calls attention to the fact that the Acrididæ—unlike their relatives, the crickets and the long-horned grasshoppers—do not stridulate with their wings, but rub the femur against the raised meshwork of veinlets upon the tegmina. Another striking difference between this family and the other families of the order is that here, alone, we get the bright coloring of the inner surface of the hind legs. These are often the only bright colors the insect possesses. It has become an axiom that insects are constantly endeavoring to show their beauty—especially if it be a secondary character, as grasshopper colors often are—and in the case of the Acrididæ this can only be done by twisting their hind legs about. Such a motion would necessarily result in friction between the femur and the tegmina, friction in irritation and increased growth, and this growth is the sound organ.

An interesting analogy which he does not mention is found in the subfamily Œdipodinæ. Lügger, in describing the Œdipodinæ, said: "The insects belonging here are mostly large and showy, often possessing bright-red, yellow or even blue wings, with black bands. Nearly all the bright-colored locusts found in the United States belong to this subfamily; most of them are very conspicuous objects in flight, when they show their color, which is at other times entirely hidden. Œdipodinæ are also very noticeable on account of the rattling noise which the males of most species produce in flight." The connection here between sound and something to be called attention to is quite marked, and while it is about as hard to tell which came first—color or sound—as it is in the proverbial case of hen or egg, doubtless Portchinsky would say that the sound was originally caused by the vigorous beating of the insect's wings in its amorous display, and is as much a secondary matter as the femoral-tegmental stridulation.

In the years that have passed since this was written I have watched many of these "amorous displays," particularly those of *Dissosteira carolina*. This species has a conspicuous yellow edge on its hind wings, seen only when the creature is in flight. It is possible for this grasshopper to sail through the air for a short distance rather noiselessly but when the wings are vibrated vigorously, as when it is hovering over a particular spot, a loud crackling sound is produced, apparently by the striking of the hind wings against the front. Whenever a male is seen thus hovering, displaying his gaudy hind wings and "sounding his castanets," one can be certain that a female is almost directly underneath him. Watching her ever so closely, I have never been able to detect that she pays the slightest attention to his serenade. Perhaps this was just my misfortune or the result of faulty observation. What I did see was that the two of them, when they came near each other worked their hind legs up and down in the way that other short-horned grasshoppers do when they make sounds by rubbing their hind legs against the front wings, but I could never hear any sounds produced.

A curious thing was noticed while experimenting on the flight of this species. I mutilated specimens in various ways and turned them loose. Almost always any individuals within a few feet of the mutilated one

turned and slowly walked toward it. Was the attraction a sound which I could not hear at the distance from which I was watching or was it odor of fluid exuding from the wounds?

As far as I know, a sound which this species makes when captured has not been noted. It quite audibly "gnashes its teeth," apparently by rubbing its mandibles against the labrum. Just what good this does the grasshopper is not clear unless it be analogous to human swearing. Possibly the mutilated specimens were "gnashing their teeth" and the sound aroused the curiosity of their neighbors.

In the United States there is no species of short-horned grasshoppers that has developed unusual structures in connection with sound-production, although many of the species make sounds in one way or another. The Acridiidae are much given to rubbing the long hind legs against the front wings. One of these insects will sit for hours on a blade of grass fiddling monotonously and, one is tempted to say, aimlessly; but can we be certain of the reasons for all of an insect's actions? Unobserved, I have watched a small boy sitting on the bank of a stream softly playing a mouth-organ. If I had asked him why he did it, the answer would probably have been "Oh! just for fun" but we can not ask the grasshopper. It is interesting to note that even immature grasshoppers sit on grass-blades and move their long hind legs up and down in just the way that would produce sounds if only they had the wings of their adult stage. Is this movement of the legs a fundamental thing and the sound which results when wings are present merely an accident or are the young practising the motions that will in later life make sounds to help them in wooing?

Among the Acridiidae in South Africa there is a genus, *Pneumora*, in which the males rub their hind legs against ridges on a greatly inflated abdomen, the latter doubtless acting much like a resonating chamber and increasing the sound. Another South African genus, *Methone*, although having a small abdomen, has greatly modified legs. The hind pair are scarcely longer than the other legs and so the creatures do not jump, but both sexes make sounds by rubbing these hind legs against ridges on the abdomen. There are two differently formed rubbing areas on the legs and two corresponding areas on the abdomen. I do not know whether two different sounds are produced or whether they are combined. One set of these structures is about equally developed in each sex but the other set is better developed in the male.

It is possible that female grasshoppers are following the lead of the males in sound-production. Sharp said:

The apparatus for producing sound was for long supposed to be confined to the male sex of grasshoppers: it was indeed known that females made the movements appropriate for producing music, but as they appeared to be destitute of instruments, and as no sound was known to follow from their efforts, it was concluded that these were merely imitative. Graber has, however, discovered that rudimentary musical organs do exist in the females of various species of *Stenobothrus*. It is true that in comparison with those of the male they are minute, but it would appear that they are really phonetic, though we can hear no sounds resulting from their use.

Graber considers that the musical pegs of Acridiidae are modified hairs, and he states that in certain females the stages intermediate between hair and peg can be found. There is apparently much variety in the structure of these instruments in different species, and even in individuals of the same species. In *Stenobothrus lineatus*, instead of pegs, the instrument consists of raised folds.

The possibility that insects make and hear sounds inaudible to man should, of course, always be kept in mind but we should distinguish between inaudibility due to the low intensity and that due to the high frequency of vibration. It would appear that, if the females of *Stenobothrus* do make sounds, man's inability to hear these sounds is due to the fact that there is not enough volume. In that case, if these grasshoppers can hear the sounds they make, they must have auditory powers very much better than man's in picking up faint intensities within man's range of audible frequencies; this is different from an ability to perceive vibrations having frequencies beyond man's audible range. The presumed auditory apparatus of the Acridiidae does not seem to have any characteristics that make it especially sensitive to sounds which, for either reason, are inaudible to man, but there does seem to be a real auditory apparatus. At least, there is in most species a thin disc-like membrane on each side of the abdomen and accessory structures which may give the insect notice of any vibrations of this "ear-drum."

The remainder of the jumping Orthoptera, the long-horned grasshoppers and the crickets, are noted musicians. They make sound by rubbing together the two front wings, the tegmina. These tegmina, fitted with a file and rasping surface, usually have a peculiar modification of the venation so as to form a tympanum or sounding board. That is, the males have these structures; the females have no modifications of the tegmina and usually do not make sounds audible to man but I have found in several cases that, if one forces the female's tegmina to rub together, a quite audible sound is produced. Furthermore, there is a structure on each front leg of each sex that looks as though it might function as an ear and that has been considered to be one. Sharp's excellent description is quoted here.

The Locustidae resemble the Acridiidae in the possession of specialized ears and sound-producing organs; neither of these is, however, situate in the same part of

the body as in Acridiidae. The ears of Locustidae are placed on the front legs, below the knee; a tympanum or a crack, giving entrance to a cavity in which the tympanum is placed, being seen on each side of each of the anterior pair of limbs. In this family, as in the Acridiidae, three kinds of ear are recognized according to the condition of the tympanum, which is either exposed or closed by an overgrowth of the integument, or in a condition to a certain extent different from either of these. The existence of ears placed on the legs is a curious fact, but it is beyond doubt in the Locustidae, and there is good reason for believing that analogous organs exist in this situation in other Insects that have special means of sound-production, such as the ants and the Termites.

The structure of these organs in the Locustidae has been investigated by Graber, and their acoustic functions placed beyond doubt, though to what special kind of sounds they may be sensitive is not ascertained, this point being surrounded by even greater difficulties than those we have discussed in the case of the Acridiidae. In the Locustidae there is a special structure of a remarkable nature in connexion with the ears. In Acridiidae a stigma is placed close to the ear, and supplies the internal structures of the organ with air. There are no stigmata on the legs of Insects, consequently admission of air to the acoustic apparatus in Locustidae is effected by means of a gaping orifice at the back of the prothorax, just over the base of the front leg; this communicates with its fellow of the other side, and from them there extend processes along the femora into the tibiae, where they undergo dilatation, so as to form vesicular cavities, one of which is in proximity to each drum of the ear. These leg-tracheae are not connected with the ordinary tracheal system; the prothoracic stigma exists in close proximity to the acoustic orifice we have described, but is much smaller than it. It is not yet clear why the acoustic apparatus should require a supply of air apart from that which could be afforded by the ordinary tracheal system. This special arrangement—to which there is hardly a parallel in Insect anatomy—has still to be accounted for; we do not know whether the necessity for it may be connected with the respiratory system or the acoustic organ.

Although the tibial ears of Locustidae are very perfect organs, there is great difficulty in deciding on the exact nature of their functions. They would appear to be admirably adapted to determine the precise locality from which a sound proceeds, especially in those cases—and they are the highest forms—in which the tympanum is placed in a cavity the external orifice of which is a slit; for the legs can be moved in the freest manner in every direction, so as to bring the drum into the most direct line of the vibrations. But as to what kinds of vibrations may be perceived, and the manner in which they may be transmitted to the nerves, there is but little evidence. . . .

The Gryllidae possess a pair of tympana on each front leg, but these organs contrast with those of the Locustidae in that the pair on each leg usually differ from one another, the one on the outer or posterior aspect being larger than that on the inner or front face of the leg.

The ears of the Gryllidae have not been so well investigated as those of the Locustidae, but are apparently of a much less perfect nature. No orifice for the admission of air other than that of the prothoracic stigma has been detected, except in *Gryllotalpa*. On the other hand, it is said that in addition to the tibial organs another pair of tympana exists, and is seated on the second abdominal segment in a position analogous to that occupied by the ear on the first segment of Acridiidae.

The possession of definite structural modifications of considerable extent and clearly fitted to make sound, together with what is apparently a specialized sound-receiving apparatus, is difficult to explain on any grounds other than that the sound is "intentionally" made and that it plays a part in the lives of the insects. Since only the males can make sounds but the females have "ears," it is generally supposed that the sounds are for the purpose of calling the females to them. But the males also have the same sorts of ears and so may be supposed to hear other males. Some years ago, while breeding crickets for the purpose of studying heredity, I had hundreds of them under rather constant observation. It seemed to me that I could tell by listening to the males whether they were courting females, defying other males, or just passing the time in song. At the same time, I was impressed with the fact that neither the females nor the other males appeared to pay much attention to the songsters. Often, of course, they would wave antennæ toward each other but so would they when no sound audible to us was being produced.

If it be true that large numbers of tree-crickets chirp in unison, as they are said to do, that would seem to be proof-positive that they hear each other, although I do not recall that it has been cited as a critical proof of this, the reason probably being that writers have taken such audition for granted. What are the facts in this case? While, as Shull (1907) has pointed out, Dolbear's formula is not very exact in all cases, still the number of chirps per minute for certain species about equals four times the temperature on the Fahrenheit scale minus 160. At this rate 100 to 120 chirps per minute is a fair rate. This gives about two chirps per second and Shull estimates that the silent interval is about twice as long as the chirp. As to the insects chirping in unison, Shull said.

I found exact synchronism to be comparatively rare, and to exist only between neighboring crickets. When accurate synchronism did occur, it affected only two individuals, sometimes three. One evening I discovered two crickets about five feet apart chirping in such accurate unison that I did not at once realize that there were two crickets. One soon stopped; the second hesitated, its chirp became weak, and it even lost a beat. After an irregular solo of several minutes, the second cricket recommenced. At the first chirp the first cricket struck a note out of time, then lost a beat, as if startled. It next voiced a half-dozen weak, uncertain chirps then the call gradually grew in intensity, until the two crickets were again chirping in exact unison.

If Shull noticed only a few cases of synchronism out of the many observations which he doubtless made in preparation for writing his interesting paper, the phenomenon may not be significant after all. Let us say that the chirps are at the rate of two a second and that each chirp lasts for one-sixth of a second, with a third of a second interval between them.

As a pure matter of chance it would happen at least "rarely" that the chirps would be synchronous within the limits of perception by ear. Shull's description of the action of the pair he noticed in which a member hesitated when the other member stopped is not very impressive. These creatures do not seem to quit chirping from fatigue. Shull counted one that chirped 2640 times without stopping. When they stop, it is usually due to some external stimulus and it would be quite natural that the stimulus that made one cricket stop would make another at least hesitate. Crickets often "miss a beat" when starting or stopping and the phrase "as if startled" may not describe that particular cricket's emotion. Shull concludes his paper as follows.

Dolbear may have gained his impression of universal synchronism¹ by observing a sporadic case of it or by actually listening to but one cricket and mistaking it for a full chorus. The intensity of sound diminishes so rapidly with increasing distance from the source, that with but one cricket chirping several feet away and the others at a greater distance an observer could easily overlook those at the greater distance. One cricket, if undisturbed, will usually perform six to eight hundred chirps without missing one, except on cool nights. Not infrequently it will perform 1500 in succession; while one "long-winded" individual which I observed continued through 2640, another 2425, a third 2228. From these figures it will be seen that breaks in the series of chirps might escape observation, and that the continuous chirping of one performer might be mistaken for a chorus in which the single crickets were not missed when they dropped out. It would thus happen that a single cricket may have been mistaken for several in unison, each performing less continuously.

Although Shull seems to have covered the ground, an illustration from my own observations may add to the evidence. Two *Æcanthus nivæus* were on one of my vines chirping in what seemed to be perfect unison. They were about six feet apart and I took a position about midway between them. Then, by careful concentration I could listen to one without paying attention to the other. One was averaging 105 chirps per minute and the other 107. Such being the case, there could not be unison, yet the chirps were so rapid and it was so difficult to keep my attention fixed on both at once that, even when I tried, I could scarcely detect the instant at which one of the insects was silent while the other was chirping. However, each was chirping quite independently of the other.

Chirping in unison, a thing that would be ideal proof that tree-crickets hear each other if it were true, does not seem to be as definitely established as one could wish it were. Of course, there might be nothing in the synchronism stories and still the crickets might hear each other. What would the crickets gain at any rate by chirping in unison? What do

¹This impression has been gained by many observers in many localities so that Dolbear is not the sole authority for it.

they gain by chirping at all? Returning to *Gryllus*, the genus that is usually meant when we speak of crickets and the one that I personally have studied most, my observations indicate that it is almost always the male that approaches the female and not the reverse. If such be the case, the female does not locate the male by his song and by this means track him down for marriage. The male approaches the female, vibrating his wings and dancing about in front of her just as many a "voiceless" insect does in front of his prospective bride. Courtship dances are common among insects and they are usually accompanied by a vibration of wings. Among crickets and their relatives, this vibration of wings is accompanied by sounds as a result of the vibrations. Is the female impressed by these sounds and does she choose the male that makes the sound most to her liking? If so, she is a much better judge of tone, pitch, or volume than man is, for few men could distinguish between the chirps of crickets of the same species when temperature and other conditions are the same.

I spent a rather amusing hour recently watching a male *Orchelimum* (one of the long-horned grasshoppers) serenading a female *Melanoplus* (one of the short-horned grasshoppers), "caressing" her with his antennæ as he sang. How long the comedy kept up I do not know. If it had not been contrary to the canons of orthodox biology, I might have believed that the expression on the face of the female *Melanoplus* was clearly one of unsatisfied desire and sadness because the males of her genus, family, and superfamily (or suborder) could not sing so sweetly. The male *Orchelimum* seemed to be thoroughly enjoying his escapade but, of course, I do not know what either was thinking. Perhaps it was wishing that the other would get off of that particular weed-stem.

The courtship as I have observed it in *Gryllus* is rather like that recently reported by Hungerford (1924, Ann. Ent. Soc. America, XVII, p. 224) for quite a different insect, an aquatic hemipteron, *Buenoa limnocaloris*. His description is as follows.

They sing their courting songs at all hours of the day or night—on cloudy days or clear days, in sunshine or shadow. In the aquarium containing the three pairs, there were times when all three males were chirping at once. But to appreciate the full significance of these amorous serenades, it is necessary to watch the behavior of the insects. The male singles out a female, maneuvers for a position some little distance beneath and behind her and begins a ticking sound as he slowly cruises nearer the object of his desire, his body aquiver with emotion. When within a half inch or so of the female, the ticking changes to a hum and is followed by a sudden dash to embrace her. If she eludes him, he begins all over again or transfers his affection to another. Sometimes when a female, aware of the attentions bestowed upon her, moves away from the chirping male, the latter will turn to follow another female

that may pass nearby, and resume his mating call. In a few cases one male has been observed to follow and chirp to another male. The sound produced by these insects is a ringing chick-chick-chick-chick like the ticking of a watch that can be heard fifteen or twenty feet away. This may continue for a minute or two, and then if the male has succeeded in drawing near the female, the note changes to a rapid twir-r-r made by a very rapid continuous series of chicks. The sound is made by the shuffling back and forth of the front femora and tibiae along the beak, both legs in unison. The roughened structures near the inner base of the tibiae and on the inner faces of the femora rub against a scraper-like device on the base of the beak. A comparison of the fore limbs and beaks of the two sexes will show the modifications developed in the male for stridulation.

The sound is an accompaniment of "courtship," not a call to bring the sexes together as the call of frogs and toads is rather well demonstrated to be and as insect calls have been supposed to be.

Distant and probably much more primitive relatives of this aquatic bug are the well-known cicadas, the "harvest-flies" or "locusts." Next to the crickets and the long-horned grasshoppers, they are the most renowned musicians among insects. Also, they rival those Orthoptera in the complication of their sound-producing organs, which are essentially a drum-head located on each side of the abdomen. This drum-head is alternately pulled by a muscle and released. A nice problem in comparative anatomy would be an investigation of possible homologies between this sound-producing organ of cicadas and what is supposed to be the sound-receiving organ of grasshoppers. Much has been written about the sound-making of these insects but probably as convenient and readable an account as any for the general reader is given by Fabre in his 'Souvenirs entomologiques,' translated by A. T. de Mattos in a volume entitled 'The Life of the Grasshopper.' The following quotation is from this translation.

In conclusion, let us ask ourselves the object of these musical orgies. What is the use of all this noise? One reply is bound to come: it is the call of the males summoning their mates; it is the lover's cantata.

I will allow myself to discuss this answer, which is certainly a very natural one. For fifteen years the Common Cicada and his shrill associate, the *Cacan*, have thrust their society upon me. Every summer for two months I have them before my eyes, I have them in my ears. Though I may not listen to them gladly, I observe them with a certain zeal. I see them ranged in rows on the smooth bark of the plane-trees, all with their heads upwards, both sexes interspersed with a few inches between them.

With their suckers driven into the tree, they drink, motionless. As the sun turns and moves the shadow, they also turn around the branch with slow lateral steps and make for the best-lighted and hottest surface. Whether they be working their suckers or moving their quarters, they never cease singing.

Are we to take the endless cantilena for a passionate call? I am not sure. In the assembly the two sexes are side by side; and you do not spend months on end in calling to some one who is at your elbow. Then again, I never see a female come

rushing into the midst of the very noisiest orchestra. Sight is enough as a prelude to marriage here, for it is excellent; the wooer has no use for an everlasting declaration: the wooed is his next-door neighbor.

Could it be a means then of charming, of touching the indifferent one? I still have my doubts. I notice no signs of satisfaction in the females; I do not see them give the least flutter nor sway from side to side, though the lovers clash their cymbals never so loudly. . . .

There is no possibility of divining or even suspecting the impression produced by the clash of the cymbals upon those who inspire it. All that I can say is that their impassive exterior seems to denote complete indifference. Let us not insist too much: the private feelings of animals are an unfathomable mystery.

Another reason for doubt is this: those who are sensitive to music always have delicate hearing; and this hearing, a watchful sentinel, should give warning of any danger at the least sound. The birds, those skilled songsters, have an exquisitely fine sense of hearing. Should a leaf stir in the branches, should two wayfarers exchange a word, they will be suddenly silent, anxious, on their guard. How far the Cicada is from such sensibility!

He has very clear sight. His large faceted eyes inform him of what happens on the right and what happens on the left; his three stemmata, like little ruby telescopes, explore the expanse above his head. The moment he sees us coming, he is silent and flies away. But place yourself behind the branch on which he is singing, arrange so that you are not within reach of the five visual organs; and then talk, whistle, clap your hands, knock two stones together. For much less than this, a bird, though it would not see you, would interrupt its singing and fly away terrified. The imperturbable Cicada goes on rattling as though nothing were afoot.

Of my experiments in this matter, I will mention only one, the most memorable. I borrow the municipal artillery, that is to say, the mortars which are made to thunder forth on the feast of the patron-saint. The gunner is delighted to lead them for the benefit of the Cicadas and to come and fire them off at my place. There are two of them, crammed as though for the most solemn rejoicings. No politician making the circuit of his constituents in search of re-election was ever honored with so much powder. We are careful to leave the windows open, to save the panes from breaking. The two thundering engines are set at the foot of the plane-trees in front of my door. No precautions are taken to mask them: the Cicadæ singing in the branches overhead cannot see what is happening below.

We are an audience of six. We wait for a moment of comparative quiet. The number of singers is checked by each of us, as are the depth and rythm of the song. We are now ready, with ears pricked up to hear what will happen in the aerial orchestra. The mortar is let off, with a noise like a genuine thunder-clap.

There is no excitement whatever up above. The number of executants is the same, the volume of sound the same. The six witnesses are unanimous: the mighty explosion has in no way affected the song of the Cicadæ. And the second mortar gives an exactly similar result.

What conclusion are we to draw from this persistence of the orchestra, which is not at all surprised or put out by the firing of a gun? Am I to infer from it that the Cicada is deaf? I will certainly not venture so far as that; but, if any one else, more daring than I, were to make the assertion, I should really not know what arguments to employ in contradicting him. I should be obliged at least to concede that the

Cicada is extremely hard of hearing and that we may apply to him the familiar saying, to bawl like a deaf man. . . .

If any one were to tell me that the Cicadas strum on their noisy instruments without giving a thought to the sound produced and for the sheer pleasure of feeling themselves alive, just as we rub our hands in a moment of satisfaction, I should not be greatly shocked. That there may be also a secondary object in their concert, an object in which the dumb sex is interested, is quite possible, quite natural, though this has not yet been proved.

Few present-day biologists would care to accept all of Fabre's conclusions in biological theory and, as to the experiment just quoted, it is quite true that the sound of an explosion is not free from criticism as a test of the ability of one cicada to hear another but it is rather curious that at least the "false audition by touch" did not come into play.

As has been previously pointed out, the only insects which have developed elaborate sound-producing structures and make sounds easily heard by man are primitive insects. For the most part, the sound-producing organs of the higher insects, at least of those which produce sounds audible to man, appear to be nothing but ordinary modifications of structure such as might be expected to arise without any particular purpose and which, having arisen, would make a noise that is purely incidental to the ordinary activities of the insect. This would not, it must be admitted, explain such elaborate modifications as are found in the wings of male crickets and their relatives or the sound-producing organs of the cicadas. If these have arisen for a "purpose" in the lives of the insects, they certainly seem to have been a magnificent experiment on the part of Nature, an experiment that did not meet with approval and was not persisted in during the evolution of higher forms. At the same time, this sound-making seems not to have been absolutely detrimental to those forms that have the structure and the habit; they are still living in spite of the fact that their music must betray their position to any enemy that has ears to hear such sounds.¹ In this connection it is to be noted that insects which make loud noises do so chiefly at night or else they are exceedingly well hidden from view, or both.

It is interesting, in connection with a study of insect sounds, to consider briefly sound-production by and the auditory powers of rattlesnakes. Many snakes vibrate the tip of their tails when they are excited. This vibration may produce a rattling in dry leaves. The rattlesnakes are peculiar in that they possess at the tip of their tail a structure that rattles by itself when the tail is vibrated. This rattling expresses emo-

¹The fact that the cicada-killing wasp, *Sphecius speciosus*, captures about as many female as she does male cicadas indicates that this insect does not hear the sounds produced by another insect in which she is clearly much interested.

tion in the sense that the tail is vibrated only or chiefly under the stress of certain emotions. In so far it is comparable with many insect sounds. Rattlesnakes have a comparatively well-developed ear-structure and, although certain features seem to be rather poorly arranged, so great an authority as Hans Gadow asserted that "snakes can hear very well." Arguing as many do when discussing insects, this would seem to be true—the rattlesnakes make a noise and they would not do so if they could not hear; furthermore, they have ear-structures. However, Manning has recently (1923, *Journal Comp. Psychology*, III, pp. 241–247) announced the results of his careful experiments as follows.

Rattlesnakes (*Crotalus*) and probably *Sistrurus* and *Ankistrodon* have a very defective sense of hearing. A few rattlesnakes were proved to hear a loud sound of 43 vibrations per second and one exceptional snake (a halfgrown *Crotalus atrox*) heard a sound of 86 vibrations per second produced in air and one of 344 vibrations transmitted through the substrate. It may seem a bold statement, but I doubt if any one rattlesnake ever heard any other snake's rattle. I doubt if a snake would even hear its own rattle were it not for direct transmission through the body. In any ordinary sense of the word, rattlesnakes at least are deaf.

Although many important investigations and interesting observations have necessarily been omitted, the foregoing does, I trust, give a fair notion of the present status of the problems connected with the sounds made by insects. Considering the sounds themselves, it is to be noted that they are, for the most part shrill. That is, they are vibrations of high frequency. Furthermore, they are usually not very loud. The "piercing note" of *Brachytrypes megacephalus*, a cricket, is said to have been heard at a distance of a mile but this probably needs confirmation. Darwin recorded that he had heard cicadas when the 'Beagle' was anchored a quarter of a mile from the South American shore but he was doubtless listening to many hundreds at once, not to a single insect. The physicists have no good measure of loudness. Miller ('The Science of Musical Sounds,' p. 53) says.

The loudness of a sound is a comparative statement of the strength of the sensation received through the ear. It is impossible to state simply the factors determining loudness. For the corresponding characteristic of light (illumination) there is a moderately definite standard, commonly called the candle power; but for sound there is no available unit of loudness, and we are dependent on the subjective comparison of our sensations. Not only are the ears of different hearers of different sensitiveness, but each individual ear has a varying sensitiveness to sounds of different pitches and, therefore, to sounds of various tone colors.

In a first study of the physical characteristics of sounds we are compelled to consider the intensity not as the loudness perceived by the ear, but as determined by what the physicist calls the energy of the vibration. Fortunately, under simple conditions and within the range of pitch of the more common sounds of speech and music, there is a reasonable correspondence between loudness and energy.

The energy, or what we will call the intensity of a simple vibratory motion, varies as the square of the amplitude, the frequency remaining constant; it varies as the square of the frequency, the amplitude remaining constant; when both amplitude and frequency vary, the intensity varies as the square of the product of amplitude and frequency; or to express it by a formula, representing intensity by I , amplitude by A , and frequency by n .

$$I = n^2 A^2.$$

Now, in the case of sounds produced by insects, the amplitude is necessarily not great. The whole insect is small; the sound-producing organ is still smaller; and the insect's muscles are not strong enough to give much "push." Therefore, and this is one way of putting it, if the insect wishes to produce a loud sound, it must make the frequency of vibration great and so produce a shrill sound. Another way of putting it and one that has far more scientific safety but far less dramatic appeal is that, unless a sound made by so small and so feeble a source as an insect is shrill, it will not be loud as judged by human ears, in fact it may not be heard by men at all and so escape comment. This refers to loudness at the source of the sound. The question as to the distance to which sounds of equal energy at the source but of different frequency of vibration can be heard need not concern us here, for in most of the cases for which biological significance has been claimed the sound-producer and the sound-receiver are near to each other.

A word concerning the reception of sound may not be out of place. Thinking only of man, Miller defined sound as "the sensation resulting from the action of an external stimulus on the sensitive nerve apparatus of the ear; it is a species of reaction to this external stimulus, excitable only through the ear, and distinct from any other sensation. . . The physicist uses the word *sound* to designate the vibrations of the sounding body itself, or those which are set up by the sounding body in the air or other medium and which are capable of directly affecting the ear even though there is no ear to hear." The tuning forks ordinarily used to give "middle C" vibrate 256 times per second. If we touch such a vibrating fork, we can "feel" the vibrations. However, the vibrations of the fork can affect us without our actually touching the fork, for it sets the surrounding air to vibrating, these "sound-waves" in the air set structures in what we call our ears to vibrating and we feel these vibrations, only we call that particular sensation "hearing." Of course, all of this is very elementary and, yet, it is desirable that we understand clearly what we mean by hearing. Our ears are sensitive to only a limited range of frequencies of vibration. This range is variously stated, but sufficiently accurate and easily remembered limits are 30 and 30,000 vibrations per

second. Now, the facts that we can "hear" only with certain special structures which we call ears and that we can hear only those atmospheric vibrations which occur more frequently than 30 per second and less frequently than 30,000 per second give us no warrant for saying that creatures differently constructed can not "hear" without special ears or can not hear other rates of atmospheric vibration.

Taking up the first possibility, we note that insects possess many structures that seem well fitted for being set into vibration by impinging sound-waves. The body itself, instead of being a soft, flabby, vibrationless structure like our bodies, is a thin shell loosely filled with viscera, or rather this shell is made up of a number of thin, hard plates suspended by flexible membranes. Physically, one would expect that each of these plates and the shell as a whole would naturally vibrate when acted upon by sound waves. If this be true and if the insect can feel the vibrations thus set up, it is logomachy to say that such a sensation is not hearing. Then there are the wings that are probably more responsive to sound-waves than the most sensitive of telephone diaphragms; also the antennæ and the palpi. One would think that the insect's body is all aquiver in this noisy world but whether its nervous system is such that it can perceive these vibrations is quite another question.

And then we have the still more difficult question of "attention." I am writing this during a quiet evening in the country and have not been conscious of the fact that my auditory structures were vibrating vigorously. Now that I force myself to think about it, the typewriter is clicking, a smouldering log in the fire-place is crackling, my wife is rustling the pages of a magazine, a child upstairs dropped a shoe, two species of Orthoptera are chirping out in the yard, an automobile passed along the street, and a distant locomotive whistled. My ears have been all aquiver but I gave no response until, in the midst of it all, I felt those vibrations which meant to me that the child was saying "Good night." Perhaps, if I had not been interested in entomology, I would not have included in the above list the Orthoptera. Perhaps, if I had been more interested in automobiles than I was, I would have noticed something about the one that passed so that I would have known how many cylinders it had or that one of them was not firing properly. It is a matter of interest and of experience. We can well believe, then, that Turner, for example, was right when he said: "The fact that an insect does not respond to a sound is no sign that it does not hear it. The response depends upon whether or no the sound has a life significance."

Also, in the case of insects, it does not seem necessary to find special structures set aside as ears. If the insects feel only the vibrations of the

surface upon which they are standing, I would be willing to call that "false audition by touch" but if they consistently perceive and, when interested, react to vibrations of various parts of their body set going by sound waves, I can see no reason for not saying that they "hear" these sounds. All of this is not to say that I believe that insects do hear in this way. I do not know; but it seems possible and a number of careful experiments make it seem even probable. This probability is really not decreased by the fact that certain groups, such as the Orthoptera and the termites, have developed what appear to be special sound-receiving organs. If they have something extra, something that other insects do not have, that may be to their advantage, depending upon how this special structure functions and also upon the need for it. Since man can hear Orthoptera make sounds, man says that what seem to be specialized ears are such and have arisen for the purpose of hearing the sounds which he hears the Orthoptera make. Also, if these structures are present in a species that does not make a sound audible to us, then that creature must be making sounds that we can not hear but that it, by aid of these structures, can hear. These ideas are fairly expressed by Sharp as follows.

The forms [of Orthoptera] in which the ears are absent are usually at the same time wingless and destitute of organs of stridulation; but, on the other hand, there are species—some of them wingless—that are, so far as is known, incapable of stridulation and yet possess these ears. It is, indeed, a matter of great difficulty to decide as to the exact function of these ear-like acoustic organs, which, we may remind the reader, are peculiar to the saltatorial Orthoptera [not strictly so], and we must refer for a full discussion of the subject to Graber's masterly works, contenting ourselves with a brief outline, which we may commence by saying that the Orthoptera with ears are believed to be sensitive to sounds by means other than these organs. This suggests that the latter exist for some purpose of perception of special sound. But if so what can this be? Only the males possess, so far as we know, effective sound-producing organs, but both sexes have the special ears; moreover, these structures are present in numerous species where we do not know of the existence of phonetic organs in either sex. Thus it appears at present impossible to accept these organs as being certainly special structures for the perception of the music of the species. It is generally thought that the females are charmed by the music of the males, and that these are stimulated to rivalry by the production of the sounds; and Dufour has suggested that this process reacts on the physiological processes of the individual. There has not been a sufficient amount of observation to justify us in accepting these views, and they do not dispose of the difficulty arising from the existence of the acoustic organs in species that do not, so far as we know, produce special sounds. It is possible that the solution of the difficulty may be found in the fact that these apparently dumb species do really produce some sound, though we are quite ignorant as to their doing so. It is well known that sounds inaudible to some human ears are perfectly distinct to others. Tyndall, in his work on Sound, has illustrated this by a fact that is of special interest from our present point of view. "Crossing the Wengern Alp with a friend," he says, "the grass on each side of the path swarmed with insects which to

me rent the air with their shrill chirruping. My friend heard nothing of this, the Insect world lying beyond his limit of audition." If human ears are so different in their capacities for perceiving vibrations, it of course becomes more probable that auditory organs so differently constituted as are those of Insects from our own may hear sounds when the best human ear can detect nothing audible. On the whole, therefore, it would appear most probable that the Orthoptera provided with acoustic organs, and which we consider dumb, are not really so, but produce sounds we cannot hear, and do so in some manner unknown to us. If this be the case it is probable that these ears are special organs for hearing particular sounds.

The termites having on their legs organs similar to those of crickets and presumed to be acoustic might, according to this argument, be expected to make these inaudible-to-man sounds since they do not make very definite sounds that are audible to man. It should be remembered that these presumed sounds are inaudible to man because they have a great frequency of vibration, not because they are lacking in loudness. Recalling that, in ordinary sounds at least, loudness varies as the product of the square of the frequency times the square of the amplitude of the vibrations, it is tempting to think that insects may by microscopically small movements rub microscopically fine ridges together in such a way as to make sounds that are really loud when received by a mechanism attuned to very short wave-lengths, that is, to a large number of vibrations per second.

Now, the straight-forward method of determining this would be to stop theorizing and construct an instrument that can detect such sounds if they are made. This will doubtless be done in the not-distant future but the task is not so easy as one might wish it to be. Consider first the biological difficulty. Suppose that we could not hear the note of the katydid and could not see the wings making motions which would indicate the possible production of sound but that we had an instrument capable of detecting the katydid's note. We might keep this instrument going from dawn to dark day after day and get no indication that the katydid makes a sound, because it makes it only at night. Even if we ran the instrument at night, the chances would be great that the insect would not be singing at the time and under the conditions in which we kept it. Those who have had much experience with keeping living insects will appreciate this difficulty. Then, the physics of the problem presents difficulties. Ordinary microphones can not be used, for they depend upon diaphragms which have a definite resonance or natural periodicities of vibration. The human ear has a much greater range than most artificial diaphragms. Furthermore, since we can not hear these sounds, no matter how much we amplify them, we require either some visible evidence of their existence or a method of heterodyning that will prove to

our ears their presence. Through the very great courtesy of the Research Department of the Westinghouse Electric and Manufacturing Company, I have had at my disposal during the past summer what is probably the best apparatus yet designed for this purpose and I have also had the benefit of the interested cooperation of Dr. Phillips Thomas of that company. We did not secure any demonstration of such sounds but, considering the difficulties and the many possible sources of error, we feel that the attempt should not be abandoned. The knowledge as to whether insects do or do not make and receive sounds that are inaudible to us will be interesting. Whether such sounds, if made, are biologically important will then be a further question. Are the insect-sounds that we can hear biologically important?

In our review of the past work on this subject we have noted the following as the most important advantages claimed for the ability of insects to make sounds: (1) to frighten enemies; (2) to warn other members of the same species that a given part of the feeding ground is preempted; (3) in the case of social insects, to call members of the colony to the defense of the nest or to a supply of food; (4) to call and to charm a prospective mate; and (5) to express the "joy of living."

The matter of frightening enemies has already been discussed as fully as seems profitable. No good proof of the importance of this effect is known to me. The second point seems to me to be too far-fetched to need discussion.

The possibility that social insects "talk" to one another is fascinating. It is difficult to believe that the many activities of a large colony are the result of mere tropisms of the individuals, although a great deal of recent work points in that direction. It still seems that there may be some real means of communication between the various members of the colony, although this involves not only definite signals but intelligence enough to give, receive, and properly act upon the signals. If all of this be granted, it still remains to discover the nature of the signals. So far as we know, insects excel man only in their olfactory sense and in their ability to perceive ultraviolet light. I am not aware of a single experiment that has furnished indisputable evidence of communication between insects by means of sound. The most common defect of such experiments, apart from the frequent doubt concerning there having been any real communication, is that the possibility of reaction to odors has not been excluded and we have many reasons for believing that insects possess a well-developed olfactory sense. The fact that faint sounds within our range of audible frequencies are made at these times has been

used as proof that communication has been by means of sounds but, in addition to this being no proof, it implies that insects have a more acute hearing for faint sounds within man's range of auditory frequency than has man, and this is not even indicated by any work known to me. If social insects communicate with each other by means of sound, it seems probable that the sounds employed have a pitch above that of man's auditory range and of this we have no proof.

The belief that sounds form an important sexual attraction in the case of a few insects, although, so far as we know, they play no part in the mating of the great majority of species, rests largely upon interpretation and the doctrine of sexual selection. After watching and listening hours upon hours in broiling sun and pitch darkness to the sounds made by male Orthoptera without getting any evidence that these sounds have a sex appeal or that the males are even thinking of mating, I confess that my feelings are best expressed by the saying "I am from Missouri and want to be shown." Experiments concerning sexual selection in the case of flies (*Drosophila*) have been carried out and sexual selection seems to have been demonstrated, but the basis upon which the selection was made still remains obscure. If male crickets, say, could be muted without injuring them in any other way, we might test their ability to get a mate in competition with musical brethren but the experiment is not one to be lightly taken up. On the other hand, if the profound modifications noted on previous pages have been brought about for the specific purpose of sound-production and by sexual selection, the experiment ought to give very definite results since, under these conditions, sound might well be expected to be very important. Since I am not convinced that sound is important in the mating even of crickets, I do not believe that these structures have arisen for this purpose and in this way. However, if the "sex calls" of Orthoptera are important, it may be that other insects make love in the same way but employ sounds of such high pitches that man can not hear them. This should be investigated but it does not necessarily follow, for crickets may have one way of getting mates and beetles, for example, another. This is brought out by Prof. T. D. A. Cockerell in a personal letter concerning my recent paper on 'Some Apparently Nonselective Characters.' He says:

As to Natural Selection, I think it is like this. Suppose you make a collection of love-letters. They would be all different. As they were (let us assume) all successful in their purpose, you would infer that the differences were not adaptive. But, in fact, each letter would represent the attempt of the organism to adapt itself to its environment. They would differ because the total result was due to the nature of the organism and the nature of the necessary adaptation. The nature of the organism is a

product of past ages. So, A, B, C, D, would each make an effort in appreciably different terms. The effort would be directed toward adaptation, but its precise form conditioned by the nature of the creature. Why should it be so, and why should results be diverse? Well, because during the past, in each particular line, certain tendencies have prevailed for reasons of the most diverse kinds and now past our finding out.

Even though it may now be past finding out why it is important that one species chirps one song while a closely related one chirps an appreciably different song, it may not be too late to discover whether or not the chirp is important at all. As to "adaptation," there has been considerable confusion. This, it seems to me, was evident in a symposium on 'Adaptation' conducted by the Entomological Society of America. Nearly every speaker mentioned some use to which an insect put a structure and then concluded that the structure arose for the purpose of being used in that way. I fear that I was quite heterodox, for I spoke in part as follows.

"Before one can either interpret or discuss an interpretation of adaptation he should have clearly in his own mind what he means by 'adaptation' and each speaker must in some way make clear to his patient audience his definition of the term.

"The human mouth can do many different things in addition to chewing and making a noise. Not infrequently we see a man putting the stem of what he calls a pipe between his jaws. Leaves of alfalfa and various other plants sold under the trade-name of 'tobacco' are put in the bowl of the pipe and ignited. This man then sucks the smoke through the stem of the pipe into his mouth, subsequently expelling the smoke either between his lips or by the way of internal passages through his nostrils. He seems to get a certain amount of pleasure and some even say profit from these actions, actions which involve a rather intricate series of anatomical—shall we say adaptations?

"The pipe was fashioned for this particular purpose and its structure may, I think, be said to be adapted to smoking in the sense in which the word adaptation should be used in this discussion but the man's teeth that hold the pipe, his mouth's connection with a pump-like arrangement in this thorax, and the internal passages between his mouth and his nostrils are merely subsequently made use of in the curious practice which he has recently and perhaps only temporarily taken up.

"Observing one of these men, I saw him fastening a notice on a bulletin board. He used his pipe like a hammer in order to drive in the pin. For this purpose the pipe functioned rather well but I do not think it could be said to be 'adapted' to driving pins even though it did drive a pin then and probably is often used in this way.

"I am told that the stem of a pipe wears a man's teeth away. Surely neither the man who uses a pipe nor the man who made it intended that this should happen. In the sense in which the word adaptation should be used in discussions concerning evolution the pipe is not adapted to wearing away human teeth even though it does do it."

Applied to the problem of insect-sounds, this line of reasoning would lead us to think that at least many of the structures by means of which insects make sounds are really not adaptations for sound-making. To have been developed by natural selection, the sounds made by these structures must have been of material advantage to the insect and proof or even fair evidence that such is the case seems to be lacking in the majority of cases. Leaving out of account for the present the Orthoptera and the cicadas, there are few or none of the sound-making insects that have well-authenticated organs of hearing or whose sound-producing organs may not quite conceivably produce the sounds by pure accident and without any purpose or profit. Until we have proof that insects in general purposely make sounds, audible to them even though inaudible to us, or that they profit by sounds which they make without intention, there is nothing in our present knowledge of the biology of insects that furnishes good ground for believing that the exceptional cases in which we hear insect-sounds are really exceptions to a rule that flies, bees, beetles and similar insects do not communicate by means of sounds. If, however, we obtain proof that insects in general do make sounds that are audible to them, even though inaudible to us, then we will have some basis for believing that insects communicate with each other in this way. As the case stands now, it seems to me that the sound-making structures of these insects were no more designed by selection (or otherwise) for that purpose than a tobacco pipe was designed to drive tacks and I even doubt the so-far published evidence that they are intentionally so used.

In the cases of Orthoptera and cicadas the presence of extreme specializations, wonderfully efficient in producing sound and apparently not used for any other purpose, gives us a reason for thinking that there is a purpose. The presence of what seems to be a definite ear in the stridulating Orthoptera is an additional reason. However, when we see that the termites, which are not known to stridulate, have the same sort of an ear as crickets and long-horned grasshoppers and that the cicadas, which produce a loud (to us) sound, probably have no ear (unless it be connected in a deafening way with the sound-producing structure), this latter reason loses some of its force. Also, the highly specialized sound-

producing mechanism of deaf rattle-snakes is, as was pointed out above, worthy of consideration in this connection. The suggested purpose of the well-developed insect sounds, a "sex call," is only imagined; it has not been proved and the chief evidence is that usually the females do not make a sound that we can hear.

If these structures have not arisen for the purpose of making sounds, why have they arisen and how? There is at present no certain answer to this question. Rugosities on the veins of insects where there is no apparent use for them are known and these are very like the "file" of a cricket's wing. There are also, among the Orthoptera, intergrades between "unmodified" venation and that of a male cricket so seemingly intended to help in producing sound. These two facts furnish material for a brief in favor of the idea that the wings of a male cricket have been developed by natural selection because it was to the advantage of the insect to chirp; but this advantage is uncertain and, even if it were certain, there would still remain the possibility that it is a secondary and accidental thing. In a former paper¹ an attempt was made to show that complicated and definite structures, including details of wing-venation, had arisen by mutation or through the action of developmental factors without any "purpose" or favoring action of natural selection. I would not be so bold as to say that this is true of the cricket's wing and the cicada's drum but I would not deny such a possibility.

At any rate, Nature has not seen fit to give the higher insects sound-producing organs that, judged by man's standards and present knowledge, can be compared in efficiency with those obtained by a few low in the phylogenetic scale. The limiting or destructive action of Nature Selection seems beyond question. It may be that sound-production, by friction and otherwise, developed among insects without any favoring or constructive action of Natural Selection, if such there be. Whether the limiting action of Selection has prevented its further development is, of course, quite uncertain but it is clear that, as far as man's unaided ears can determine, either (a) such development has not been greatly favored and so, presumably, is not of value to the insects or else (b) there is little force in the favoring action of Natural Selection. It is, of course, possible to suppose that, as insects became more "advanced," they acquired the power of communicating with each other by means of sounds of such

¹Lutz, Frank E., 1924, 'Apparently non-selective characters and combinations of characters,' *Annals N. Y. Academy of Sciences*, XXIX, pp. 181-282.

short wave-length as to be inaudible to their vertebrate enemies,¹ If this were true it would, indeed, be dramatic and of great biological interest, but we have yet to discover even the production by insects of such sounds, to say nothing of proving that insects can receive and intelligently react to them.

¹Cockerell, Miller, and Printz (1914, *Zoologischen Anzeiger*, XLIV, p. 434), discussing the auditory ossicles of rodents, said: "Thus there appears to be a definite relation between the size and shape of the ossicles and the voice of the animals, although this can at present only be stated in general terms. The ossicles, then, exhibit a certain parallelism with recognition marks, probably tending to make the rodents especially sensitive to the voice of their species. Perhaps some day an energetic student will collect phonographic records of the voices of mammals, and it will be possible to determine more exactly how these are related to the structure of the ears. It may be also noted that the chirping Orthoptera, much preyed on by mice, often have very high pitched 'voices,' so much so that they are sometimes inaudible to some human beings. It may be advantageous to the Orthoptera to be able to call one another in notes so shrill that to some animals they are inaudible, but it may also be advantageous to the mice to be well fitted for hearing those high sounds."

Article VII.—SOME FISHES COLLECTED BY THE THIRD ASIATIC EXPEDITION IN CHINA¹

BY HENRY W. FOWLER²

The fishes reported in this paper were sent to The American Museum of Natural History by its Third Asiatic Expedition. They are represented by several lots, chiefly from Hsing Lung Shan (Eastern Tombs region, Chihli Province, North China) and vicinity in August 1921 and Ningkwo in the Province of An-hwei Central China during September and October of the same year. All from these two localities were collected by Mr. Clifford H. Pope. Preliminary notices have been given of two new species.³

The specimens embraced in this study of the Third Asiatic Expedition's material number 1103, of which the majority are cyprinids. Descriptions are given of seventeen species of special interest, as imperfectly or little known. The other species are noticed with condensed computations of their variation, often supplemented with discussion. I have also included several notes on types or rare species in the Academy of Natural Sciences of Philadelphia and used several series in their collections of both Chinese and Japanese specimens in comparison. Figures illustrating two new cyprinids that I have previously described, a little-known loach, and some of the salient color-variants of the Chinese *Cobitis taenia* are given.

Acknowledgment is due to Mr. John T. Nichols and The American Museum of Natural History for the loan of this material for study and the reservation of a set of the duplicate specimens for the museum of the Academy of Natural Sciences of Philadelphia.

ENGRAULIDÆ

***Mystus nasus* (Schlegel)**

Head contained $6\frac{2}{5}$ to $6\frac{4}{5}$ times in length to base of caudal; depth, 6 to $6\frac{1}{4}$. Dorsal III, 11, 1; anal II, 92 to 107; pectoral VI, 11 or 12; ventral I, 6. Scales 72 to 76 in lateral line to caudal base, and 3 more on latter; 12 or 13 scales transversely between dorsal and ventral origins; 18 to 23 predorsal scales; abdominal scutes 19 or 20 to ventral origin, 28 to 33 following. Head width $2\frac{2}{3}$ to 3 times in its length; snout $4\frac{1}{2}$ to $5\frac{1}{2}$; eye $5\frac{1}{3}$ to 6; maxillary $\frac{3}{5}$ to $1\frac{1}{5}$; interorbital $3\frac{1}{8}$ to $3\frac{2}{5}$; first branched dorsal ray $1\frac{1}{10}$ to $1\frac{1}{8}$; length of caudal $1\frac{4}{5}$ to $1\frac{5}{6}$; pectoral $1\frac{1}{3}$ to $1\frac{2}{5}$; ventral $2\frac{1}{8}$ to $2\frac{1}{4}$.

¹Publications of the Asiatic Expeditions of The American Museum of Natural History. Contribution No. 38.

²Of the Academy of Natural Sciences of Philadelphia.

³American Museum Novitates, No. 38, May 25, 1922, pp. 1-2; and No. 83, July 25, 1923, pp. 1-2.

Body strongly compressed, deepest at dorsal and ventral origins, predorsal edge convex and postdorsal with only slight median keel.

Head acuminate, strongly compressed, flattened sides but slightly approximate below. Snout protrudes rather obtusely, length $\frac{3}{5}$ its width. Eye without distinct lid, adipose tissue covering over; center about first fourth in head, slightly more backward in smaller example. Mouth large, narrow, mandible tip midway in snout length. Maxillary very long, extends beyond angle of preopercle, though not quite to gill-opening in younger example and to below gill-opening and slightly beyond pectoral origin in larger example. Teeth in jaws or along maxillary its entire length, and in mandible edges uniserial; small patch each side of vomer and another moderate uniserial row on each palatine. Tongue small free knob, advanced, edentulous. Nostrils together, front one at last third in snout, and hind one much the larger. Interorbital broadly convex. Opercles smooth.

Gill-opening extends forward opposite hind eye edge, connecting membranes moderate. Gill-rakers 18 or 19 + 22, fine, lanceolate, equal in length to gill-filaments, which are as long as eye. Pseudobranchiæ $\frac{1}{4}$ the length of gill-filaments. Isthmus a long, slender, trenchant keel.

Scales caducous, thin, rather narrowly imbricated, cycloid. Row of broad scales extends over greater part of anal basally, also some small scales on caudal base. Scaly flap in ventral axil $\frac{2}{5}$ length of fin. Scales with 1 or 2 basal radiating striæ; circuli basally 114 to 120; apical striæ 9 or 10, fine, largely reticulate. Abdominal scutes sharply pointed.

Dorsal inserted slightly behind ventral origin, first branched ray longest and depressed backward farther than others. Anal low, mostly uniform, begins at first $\frac{2}{5}$ in combined head and trunk, excluding caudal, slightly behind middle in smaller example. Caudal continuous with anal, median upper rays longest, forming a point. Pectoral without filaments, reaches slightly beyond ventral; longest filaments reach midway in combined head and trunk, without caudal, to a distance contained $2\frac{1}{4}$ times in head and trunk, in smaller example, though in all cases at least to anal origin. Ventral reaches $\frac{1}{4}$ the distance to anal, nearly $\frac{1}{3}$ in young. Vent close before anal.

Color in alcohol, faded pale brown, sides and lower surface very pale. Slight neutral-brown tint at predorsal. Iris pale slaty (doubtless silvery white in life). Fins pale, slightly dotted with pale dusky on dorsal basally.

Length 283 to 310 mm.

Five examples from Ningkwo.

Kreyenberg and Pappenheim¹ discuss the variation of the length of the maxillary, contending for *Coilia brachygnathos* that "unsere sämtlichen Exemplare grosse wie kleine, zeigen nur das obige Verhalten." It seems quite likely, therefore, that smaller or younger examples usually, if not always, have shorter maxillaries.

FLUTIDÆ

Fluta alba (Ziuew)

Eleven from Ningkwo, 335 to 533 mm. All gray-brown, paler below. Sides and above variously though finely reticulate, spotted or marbled

¹1909, Abh. Ber. Mus. Magdeburg, II, Heft 1, p. 10.

with dusky-brown. Often a dark median lateral line more or less complete. In some examples dark mottling extends more or less completely over belly and under surface, sometimes only for short space behind gill-opening. Again, dark specks on back obsolete or absent and usually three dark median parallel lines down back. Some examples may have spots very fine or absent so back uniform grayish in appearance and belly pale.

MASTACEMBELIDÆ

Mastacembelus sinensis (Bleeker)

Head contained 6 to $6\frac{4}{5}$ times in length to base of caudal; depth $10\frac{3}{5}$ to 12. Dorsal spines XXXIV, vary XXXI to XXXV; anal spines III. Snout $3\frac{1}{2}$ to $3\frac{3}{5}$ times in head; eye 8 to $8\frac{1}{5}$; mouth cleft $3\frac{4}{5}$ to $4\frac{1}{8}$; interorbital 8 to 9.

Body well compressed, deepest just before vent. Head width 3 to $3\frac{2}{3}$ times in its length. Snout conic, compressed, ends in a fleshy tip, width 2 to $2\frac{1}{8}$ in its length. Eye center at about first third in head; diameter $2\frac{1}{8}$ to $2\frac{1}{5}$ in snout, little greater than interorbital. Jaws slender, lower shorter, inferior. Maxillary nearly reaches opposite eye. Teeth small, conic, in narrow bands in jaws. Lips fleshy, moderate. Nostrils appear as a pair of short fleshy tubes each side of snout tip; hind nostril a simple pore at last sixth in snout. Interorbital nearly level. Preorbital spine strong, below front of eye. Tail $1\frac{1}{2}$ to $1\frac{3}{5}$ times in combined head and trunk. Pectoral 4 times in head; caudal $2\frac{1}{2}$ to 3.

Color in alcohol brownish generally, under surface of head and belly paler to creamy. Broad dark or dusky-brown lateral band, starting as line from snout tip across side of head, then broadening over greater part of side to caudal base. This band sometimes entirely uniform, speckled, dotted irregularly, or with 40 or more narrow pale vertical lines. Back with dusky reticulations, also lower side of abdomen. Some may extend well over basal portions of soft vertical fins. Often basal portions of last more or less dark or neutral and edges narrowly pale. Belly often immaculate white, sometimes finely reticulated with brownish. Some examples largely uniform or with markings very faint. Often a distinct pale streak runs along upper side of back delimiting upper border of dark lateral band and this with more or less regular indentures to form pale transverse lines.

Length 126 to 228 mm.

Seventeen from Ningkwo.

CATOSTOMIDÆ

Myxocyprinus asiaticus (Bleeker)

Head contained $4\frac{2}{5}$ times in length to base of caudal; depth $2\frac{1}{3}$. Dorsal v, 48, i; anal iv, 10, i; pectoral i, 17; ventral i, 10. Scales 50 in lateral line to caudal base and 3 more on latter; 13 scales above lateral line, 8 below; 19 predorsal scales. Head width $1\frac{1}{2}$ times in its length; snout $2\frac{1}{10}$; eye 6; least depth of caudal peduncle $2\frac{1}{2}$; first branched dorsal ray $2\frac{4}{5}$; first branched anal ray $1\frac{1}{10}$; lower caudal lobe $3\frac{3}{4}$; pectoral $4\frac{1}{8}$; ventral $4\frac{1}{2}$.

Body strongly compressed; back greatly compressed, elevated and its front profile strongly inclined, edge but slightly keeled; greatest depth at origin of dorsal. Caudal peduncle strongly compressed, long as deep.

Head small, moderately compressed sides but little flattened and scarcely approximated below. Snout obtuse, convex over surface, length $\frac{7}{8}$ its width. Eye small, midway in head length; diameter $2\frac{1}{3}$ in snout, 3 in interorbital. Mouth small, inferior. Premaxillaries protractile downward. Lips moderately small, fleshy, plaited. Nostrils small, together; front one pore-like, with cutaneous rim, at last fourth in snout; hind one a crescentic slit. Interorbital broadly convex. Suborbitals rather narrow.

Gill-opening extends forward to opposite last fourth of head. Gill-rakers 13+19, flexible, lanceolate, contained $2\frac{1}{2}$ times in gill-filaments, which equal eye in length. Pseudobranchiæ rather small, about $\frac{2}{5}$ the length of gill-filaments.

Scales in even longitudinal series; breast and belly covered with small scales; row of smaller basal scales on anal and several rows on caudal; head naked and a narrow naked median predorsal strip; no scaly axillary flaps. Scales with 22 to 33 basal radiating striæ; basal circuli 61 to 66; apical radiating striæ 13 to 15. Lateral line complete, midway along side from suprascapula to caudal base; tubes slender, simple and well exposed over each scale exposure to its hind edge.

Dorsal very long basally, inserted slightly nearer pectoral origin than ventral; front lobe of fin $1\frac{2}{3}$ its length, rounded. Anal begins well posteriorly, much nearer caudal base than ventral origin; depressed fin reaching about $\frac{1}{3}$ in caudal; first branched ray longest. Caudal deeply forked, lower lobe a little the longer. Pectoral broad, not quite reaching ventral. Ventral like pectoral, reaches $\frac{2}{3}$ to anal. Vent close before anal.

Color in alcohol, deep dusky-brown, center of each scale with darker shade to form slightly darker longitudinal streaks. Neutral-slaty on cheek and below eye, also upper hind side of head, and on all fins. Upper caudal lobe, lips, chin and under surface of head pale or whitish.

Length 288 mm.

One example, bought twenty miles from Ningkwo, in Ching Tsui Ho on way to Wuhu.

CYPRINIDÆ

Cyprininæ

Carassius auratus (Linnæus)

Head contained $2\frac{1}{2}$ to $3\frac{1}{5}$ times in length to caudal base; depth $2\frac{1}{4}$ to $2\frac{1}{2}$. Dorsal II, I, 16, I to 18, I; anal II, I, 5, I. Scales 26 to 28 in lateral line to caudal base and 2 or 3 more on latter; 7 scales above lateral line, 6 below; 13 predorsal scales. Snout $3\frac{1}{8}$ to $3\frac{2}{3}$ times in head; eye $3\frac{1}{8}$ to 5; maxillary $3\frac{1}{3}$ to $3\frac{2}{3}$; interorbital $2\frac{1}{3}$ to $2\frac{3}{5}$.

Color in alcohol dull brownish generally above, below little paler. Fins grayish, sometimes ends of paired ones a little darker.

Length 115 to 153 mm.

From Hsing Lung Shan August 7, 1921, 93 examples; from twenty-six miles south of Hsing Lung Shan, August 12, 1921, 83 examples; Ningkwo, 3 examples.

Barbinæ**Hemibarbus labeo** (Pallas)

Head contained $3\frac{1}{4}$ to $3\frac{1}{2}$ times in length to caudal base; depth 4 to 5. Dorsal III, 7, 1; anal III, 6, 1. Scales 40 to 48 in lateral line to caudal base, and 3 more on latter; 6 or 7 scales above lateral line, 5 or 6 below; 11 to 13 predorsal scales. Snout $2\frac{1}{8}$ to $2\frac{2}{5}$ times in head; eye $3\frac{1}{4}$ to $4\frac{2}{3}$; maxillary $2\frac{3}{5}$ to 3; interorbital $3\frac{1}{2}$ to 4; first branched dorsal ray $1\frac{1}{10}$ to $1\frac{1}{8}$; first branched anal ray $1\frac{3}{5}$ to $1\frac{3}{4}$; caudal $1\frac{1}{8}$ to $1\frac{1}{5}$; pectoral $1\frac{2}{5}$ to $1\frac{1}{2}$; ventral $1\frac{3}{4}$ to 2. Pharyngeal teeth 1, 3, 5—5, 3, 1, hooked, compressed, with well-developed grinding surfaces. Scales with 15 to 19 obsolete weak apical striæ; circuli moderate, finer basally.

Color in alcohol with row of 8 or 9 deep brown spots close along and above lateral line, most distinct or contrasted in young. On back and sides base of each scale with dark spot. Dorsal and caudal with several rows of dusky spots on outer portions.

Length of largest 244 mm.

Two from Hsing Lung Shan, August 7, 1921; six from Ningkwo, September 15 to October 15, 1921.

For comparison only a few young examples in the Academy from the Iwaii River at Ichinoseki, Japan, representing the nominal *Gobio barbus* Schlegel, which appears in every way the same, as admitted by Berg. These examples show:

Head contained $3\frac{1}{5}$ to $3\frac{1}{3}$ times in length to base of caudal; depth 4 to $4\frac{3}{4}$. Dorsal I, I, 7, 1; anal III, 6, 1, rarely III, 7, 1. Scales 40 to 42 in lateral line, occasionally 39 or 44, to caudal base and 2 or 3 more on latter; 8 scales, often 7, above lateral line; 6 scales below lateral line, seldom 5; 13 to 17 predorsal scales. Snout $2\frac{2}{5}$ to $2\frac{4}{5}$ times in head; eye $2\frac{7}{8}$ to $3\frac{4}{5}$; maxillary $3\frac{1}{8}$ to $3\frac{1}{3}$; interorbital 4 to $4\frac{1}{2}$. Pharyngeal teeth 1, 3, 5—5, 3, 1, seldom 1, 2, 5—5, 2, 1 or 1, 2, 5—5, 3, 1.

Length 54 to 62 mm.

Oshima says that *Hemibarbus maculatus*¹ from China differs only in color. In alcohol the nominal *Hemibarbus joiteni* Jordan and Starks is said to be "pinkish yellow, with a longitudinal series of eight large spots above the lateral line; smaller spots irregularly placed on back and sides; dorsal and caudal with similar black spots; other fins without markings. Although faint dark spots are present in the young specimen of *Hemibarbus labeo*, they are not permanent; the color of the adult is always uniform grayish-brown." My examples show traces of all these markings, though now apparently greatly faded.

Gobioninæ**Gobio gobio** (Linnæus)

Head contained $3\frac{1}{4}$ to $3\frac{1}{2}$ times in length to base of caudal; depth $4\frac{1}{4}$ to $4\frac{3}{4}$. Dorsal II, 7, 1; anal II, 6, 1. Scales 38 in lateral line to caudal base and 2 more on latter; 6 scales above lateral line, 5 below; 14 to 18 predorsal scales. Snout $2\frac{3}{5}$

¹1919, Ann. Carnegie Mus., XII, Nos. 2-4, p. 212.

to $2\frac{7}{8}$ in head length; eye $3\frac{4}{5}$ to $5\frac{1}{5}$; maxillary $3\frac{1}{3}$ to $3\frac{1}{2}$; interorbital $3\frac{2}{5}$ to 4. Pharyngeal teeth, 3, 5—5, 3, hooked, with well-developed grinding-surfaces. Scales with 13 to 18 apical radiating striæ; superior and inferior circuli coarse, basal very fine.

Color in alcohol brownish-olive above, with row of 6 to 10 median lateral blackish blotches, usually closer behind, and lower whitish surface strongly contrasted. On back, following scale courses longitudinally, there are rows of dusky spots, mostly appearing as longitudinal lines. Dusky streak from side of snout below nostrils to eyes. Dorsal and caudal grayish with 5 to 7 transverse rows of blackish spots, on latter more as lines. Blackish blotch in pectoral axil. Lower fins and barbels whitish.

Length 48 to 100 mm.

Forty-three from Hsing Lung Shan, August 7, 1921; one from Ning-kwo with the depth of the body contained $6\frac{1}{5}$ in the length to the caudal base, and lips and lower front surfaces of the barbels strongly papillose, sides also with five dark blotches.

A comparison of the European material in the Academy shows:

Head contained $3\frac{1}{4}$ to 4 times in length to base of caudal; depth $3\frac{3}{5}$ to $4\frac{4}{5}$. Dorsal III, 7, I; anal III, 6, I. Scales 34 to 40 in lateral line to caudal base and 2 or 3 more on latter; 5 to 7 scales above lateral line, usually 6; 4 or 5 scales below lateral line; 14 to 17 predorsal scales. Snout $2\frac{1}{8}$ to $2\frac{4}{5}$ times in length of head; eye $3\frac{1}{8}$ to $4\frac{7}{8}$; maxillary $2\frac{7}{8}$ to $3\frac{1}{2}$; interorbital $3\frac{1}{5}$ to $4\frac{1}{8}$. Pharyngeal teeth 3, 5—5, 3.

Length 70 to 172 mm.

These examples from Nürnberg, Germany; Leyden, Holland; Lake Lucerne, Switzerland; Arno River, Italy.

Several little-known species have been described from China. *Gobio argentatus* Sauvage and De Thiersant¹ differs in many respects from *Gobio gobio*, as the presence of seven branched anal rays, two rows of scales between the lateral line and the base of the ventral fin; and the color-pattern and fins without spots, though a bluish lateral band is present. Kreyenberg and Pappenheim identify examples with *Gobio argentatus*,² but they give the head as contained 4 to $4\frac{1}{5}$ times in the body and $3\frac{1}{2}$ to 4 scales below the lateral line. In most every other way their specimens appear to agree with mine.

Gobio nitens Günther³ is described with five scales below the lateral line, though with but two rows between the lateral line and the base of the ventral fin. It is, however, without barbels, in which it agrees with *Gobio imberbis* Sauvage and De Thiersant,⁴ which in turn differs.

Gobio nigripinnis Günther⁵ is another species without barbels but, as its specific name indicates, is with blackish fins.

¹1875, Ann. Sci. Nat., (6) I, Zool., p. 9. Yang-tze Kiang.

²1908, Sitzs. Ges. Naturf. Freund. Berlin, 1908, p. 97. Tuntingsee, Hankau.

³1873, Ann. Mag. Nat. Hist., (4) XII, p. 246. Shanghai.

⁴1875, Ann. Sci. Nat., (6) I, Zool., p. 9. Yenkiatsoun (S. Shen-si).

⁵1873, Ann. Mag. Nat. Hist., (4) XII, p. 246. Shanghai.

Gobio nummifer Boulenger¹ does not seem to differ from *Gobio gobio*. It is described with six round black spots along the body and tail above the lateral line.

***Gobio wolterstorffi* Regan**

Head contained $2\frac{3}{5}$ to $3\frac{1}{4}$ times in length to base of caudal; depth 4 to 5. Dorsal III, 7, I; anal III, 6, I. Scales 34 in lateral line to caudal base and 2 more on latter; 5 scales above lateral line, 4 below; 12 predorsal scales. Snout $3\frac{1}{3}$ to $3\frac{1}{2}$ times in length of head; eye $3\frac{1}{8}$ to $3\frac{1}{5}$; maxillary 3 to $3\frac{1}{4}$; interorbital 3 to $3\frac{1}{5}$. Pharyngeal teeth 2, 5—5, 3, hooked, some of upper broadly compressed, with broad grinding surfaces. Scales with 15 to 18 apical radiating striæ; circuli above and below moderate, converging finely basally.

Color in alcohol pale brownish above, with olive tinge on back, which mottled coarsely with blackish spots very irregularly. Sides and under surface whitish, with silvery reflections on sides of head. Each tube of lateral line with black spot close above and below. Iris silvery. Fins all pale, lower whitish.

Length 20 to 93 mm.

From Hsing Lung Shan, August 7, 1921, 2 examples; from twenty-six miles south of Hsing Lung Shan, August 12, 1921, 25 examples.

***Pseudogobio rivularis* (Basilewsky)**

Head contained $3\frac{2}{5}$ times in length to base of caudal; depth $4\frac{4}{5}$ to $5\frac{1}{4}$. Dorsal II, 6, I or II, 7, I; anal II, 5, I. Scales 31 to 35 in lateral line to caudal base and 2 more on latter; 5 or 6 scales above lateral line, 4 below; 11 or 12 predorsal scales. Snout $2\frac{1}{8}$ to $2\frac{1}{6}$ times in length of head; eye $3\frac{7}{8}$ to $4\frac{1}{10}$; maxillary $3\frac{2}{5}$ to $3\frac{3}{4}$; interorbital $3\frac{1}{3}$ to $3\frac{1}{2}$. Pharyngeal teeth 2, 4—4, 2, hooked, with narrow grinding-surfaces. Scales with 7 to 10 apical radiating striæ; circuli coarse above and below, converging finely basally.

Color in alcohol pale brownish on back, mottled obscurely with darker. Back with 5 broad dark saddles, each a little narrower than interspaces. Sides with about 7 very pale or obscure round blotches made up of minute grayish dots, more or less uniform in size and about equal to eye-diameter, distributed along middle of side or on line of vertebral axis. Dusky line from side of snout to eye and narrower less defined line from snout tip to above nostrils. Fins pale. Dorsal with 4 series of dusky spots, each dark blotch on rays only. Caudal only with 4 transverse dark bands, each inclined backward, and a small conspicuous median black spot, much less in diameter than half of pupil, at caudal base. Other fins all pale to whitish, though each with pale to obscure dusky median blotch or shade.

Length 43 to 56 mm.

From twenty-six miles south of Hsing Lung Shan, August 7, 1921, 3 examples.

Günther notes under *Pseudogobio sinensis* that the black caudal spot disappears with age.²

¹1901, Proc. Zoöl. Soc. London, I, p. 269, Pl. XXIII, fig. 2. Ningpo.

²1873, Ann. Mag. Nat. Hist., (4) XII, p. 247.

Saurogobio dabryi Bleeker

Head contained $3\frac{2}{3}$ to $4\frac{4}{5}$ times in length to base of caudal; depth $4\frac{3}{5}$ to $8\frac{1}{4}$. Dorsal III, 8, I, once III, 7, I; anal III, 6, I. Scales 36 to 47 in lateral line to caudal base and 2 more on latter; 4 to 6 scales above lateral line, 3 or 4 below; 11 to 13 predorsal scales. Snout contained 2 to 3 times in length of head; eye $3\frac{3}{5}$ to 5; maxillary $3\frac{1}{8}$ to $3\frac{1}{4}$; interorbital $3\frac{1}{2}$ to $4\frac{1}{8}$.

Body moderately compressed, slender, long, deepest at dorsal origin. Caudal peduncle well compressed; its least depth contained $2\frac{1}{3}$ to $2\frac{2}{5}$ times in its length, $2\frac{7}{8}$ to $4\frac{1}{3}$ in head.

Head moderate, slightly compressed, with flattened sides scarcely constricted below, width $1\frac{3}{4}$ to $1\frac{4}{5}$ in its length. Snout conic, upper profile with a slight depression just behind its tip, as long as broad; with age its width is contained $1\frac{1}{5}$ times in its length. Eye elevated, its center midway in length of head; its length contained $1\frac{1}{5}$ to 2 times in length of snout, $1\frac{1}{5}$ in interorbital, except that the latter is less than the eye in young. Mouth small, inferior, mandible depressed. Maxillary concealed, reaches front nostril, and with a fleshy barbel from subterminal outer face, $1\frac{1}{2}$ to $1\frac{4}{5}$ in eye. Lips narrow, soft, fleshy, coarsely papillose. Nostrils together, within last fourth of snout; hind one much the larger and mostly concealed by posterior cutaneous flap of front one. Interorbital broadly concave. Suborbitals narrow, pre-orbital longer than eye. Occipital fontanel as long as eye.

Gill-opening extends forward opposite hind eye edge. Gill-rakers 2+14, short, low, compressed papillæ, greatly less than gill-filaments, which contained $1\frac{3}{4}$ in eye. Pseudobranchiæ $\frac{2}{3}$ of gill-filaments. Inside of pharynx coarsely papillose. Pharyngeal teeth small, compressed, or pointed without terminal hooks or grinding-surfaces.

Scales with 8 to 56 slightly waved apical striæ, about 8 to 34 in young; apical circuli 35 to 38, imperfect. Scales firmly adherent, in even longitudinal rows, well exposed; few scales on caudal base; breast, anterior part of belly medially and head naked. Scaly pointed flap in ventral axil, $2\frac{2}{5}$ in fin. Lateral line slopes a little low at first, then runs midway over ventral and along side of caudal peduncle to caudal base. Tubes in lateral line slender, simple, half way over each scale exposure.

Dorsal origin midway between snout tip and anal origin, upper fin edge slightly concave; depressed fin contained $1\frac{3}{5}$ to $1\frac{3}{4}$ in the distance to caudal base; first branched ray $1\frac{1}{6}$ to $1\frac{1}{3}$ in head. Anal origin a little nearer caudal base than last dorsal ray base; depressed fin contained $1\frac{2}{5}$ to $1\frac{3}{4}$ times in the distance to caudal base; first anal ray $1\frac{1}{2}$ to $2\frac{1}{8}$ in head. Caudal deeply forked, pointed lobes equal, $4\frac{1}{4}$ to $4\frac{2}{5}$ in combined head and trunk. Pectoral reaches $1\frac{1}{6}$ to $1\frac{1}{3}$ to ventral, length $1\frac{1}{10}$ to $1\frac{1}{4}$ in head. Ventral inserted below third to fifth dorsal ray bases, depressed fin contained 2 to $2\frac{1}{8}$ times in distance to anal origin; fin contained $1\frac{1}{4}$ to $1\frac{2}{3}$ in head.

Color in alcohol pale olivaceous-brown, edge of each scale broadly and slightly darker. Grayish median lateral streak close along and above lateral line, with about 10 to 14 obscure darker spots. Dorsal and caudal grayish terminally, other fins whitish. Iris brownish.

Length 26 to 252 mm.

From Hsing Lung Shan, August 7, 1921, 6 examples; twenty-six miles south of Hsing Lung Shan, August 12, 1921, 8 examples; Ningkwo, An-hwei Province, 14 examples.

Longurio athymius Jordan and Starks¹ is synonymous. It is shown, apparently erroneously, with the breast and chest scaled.

***Paraleucogobio notacanthus* Berg**

Head contained $3\frac{2}{5}$ to $3\frac{2}{3}$ times in length to base of caudal; depth $3\frac{1}{2}$ to $3\frac{3}{4}$. Dorsal III, 7, 1; anal III, 6, 1. Scales 35 to 36 in lateral line to caudal base and 2 or 3 more on latter; 5 scales above lateral line, 4 below; 12 or 13 predorsal scales. Snout $3\frac{1}{3}$ to $3\frac{2}{5}$ times in its length; eye 4 to $4\frac{2}{5}$; maxillary $3\frac{1}{3}$ to $3\frac{3}{5}$; interorbital $2\frac{3}{4}$ to $2\frac{9}{10}$. Pharyngeal teeth, 3, 4—5, 3, hooked, with grinding-surfaces. Scales with 10 to 20 basal radiating striæ; circuli moderate, finely convergent basally.

Color in alcohol, back olivaceous, each row of scales marked with a longitudinal dusky band, made up of blackish dots. Along middle of side longitudinal blackish band, little less in width than eye. Dorsal grayish, with blackish blotch above forward. Caudal grayish, with dusky clouding basally in center. Other fins all more or less whitish.

Length 68 to 90 mm.

From Hsing Lung Shan, August 7, 1921, 27 examples.

***Sarcocheilichthys lacustris* (Dybowski)**

Head contained $4\frac{1}{5}$ to $4\frac{2}{5}$ times in length to base of caudal; depth $3\frac{1}{5}$ to $3\frac{1}{3}$. Dorsal III, 7, 1; anal III, 6, 1. Scales 38 to 40 in lateral line to caudal base and 3 or 4 more on latter; 6 or 7 scales above lateral line, 5 or 6 below; 14 to 16 predorsal scales. Snout $2\frac{3}{5}$ to $2\frac{3}{4}$ in head length; eye $4\frac{2}{5}$ to $4\frac{1}{2}$; maxillary $3\frac{3}{4}$ to $4\frac{1}{4}$; interorbital $2\frac{1}{5}$ to $2\frac{1}{2}$.

Body compressed, moderately robust, deepest at dorsal origin and edges all convexly rounded. Caudal peduncle well compressed, its least depth $1\frac{1}{5}$ to $1\frac{1}{3}$ in its length or $1\frac{1}{2}$ to $1\frac{2}{3}$ in length of head.

Head small, compressed, flattened sides not convergent especially above or below, lower profile a little more inclined; width $1\frac{2}{5}$ to $1\frac{3}{4}$ in its length. Snout obtusely convex, length $\frac{3}{4}$ to $\frac{4}{5}$ its width. Eye with hind pupil edge midway in length of head; $1\frac{1}{3}$ to $1\frac{3}{4}$ in snout, 2 to $2\frac{1}{8}$ in interorbital. Mouth inferior, small. Maxillary concealed, reaches opposite hind nostril. Small barbel on maxillary above near end of expansion. Lips smooth, fleshy, not extending across mandible, folded deeply at each side. Mandible spatulate, horny, firm and firm bony median surface opposite in middle of upper jaw. Nostrils together, in last third of snout; front one a simple pore with broad marginal posterior flap, exposing hind one in a crescent. Interorbital broadly convex.

Gill-opening extends forward opposite last third of head, not to eye. Gill-rakers 2+4, short rudimentary tubercles. Gill-filaments as long as eye. Pseudobranchiæ $\frac{3}{5}$ the length of gill-filaments. Pharyngeal teeth, 2, 5—5, 2, compressed, hook at end of each and grinding-surfaces moderate.

Scales with 38 to 40 apical radiating striæ; 48 basal circuli. Scales firmly adherent in even longitudinal rows, all well exposed; caudal base scaled; small scales cover breast; axillary ventral scale $\frac{2}{5}$ the length of fin. Lateral line slopes slightly

¹1905, Proc. U. S. Nat. Mus., XXVIII, p. 197, Fig. 3. Chemulpo.

at first until midway in depth; tubes simple, small, each one exposed over basal third of scale. Row of few tubercle scars around border of upper jaw above lip, also few below nostril and front of eye below.

Dorsal origin much nearer snout tip than caudal base, upper edge of fin concave; length of fin contained $2\frac{1}{8}$ to $2\frac{1}{5}$ times in the distance to caudal base; first branched dorsal ray 4 to $4\frac{1}{3}$ in combined head and trunk. Anal inserted close behind depressed dorsal tip, or a little nearer caudal base than dorsal origin; length of depressed fin $1\frac{1}{4}$ to $1\frac{1}{2}$ in the distance to caudal base; first branched anal ray $1\frac{1}{3}$ to $1\frac{2}{5}$ in head. Caudal deeply forked, lobes broad, even; length of fin contained $3\frac{3}{5}$ to $3\frac{2}{3}$ times in combined head and trunk. Pectoral reaches $\frac{3}{4}$ to $\frac{4}{5}$ to ventral; length of fin 1 to $1\frac{1}{8}$ in head. Ventral inserted slightly behind dorsal origin, depressed fin reaches $\frac{3}{4}$ to $\frac{4}{5}$ to anal; length of fin $1\frac{1}{4}$ to $1\frac{1}{3}$ in head.

Color in alcohol deep brown generally, each row of scales longitudinally with deeper or median dusky streak. Fins all with neutral-slaty or dusky, especially terminally and edges narrowly whitish. Bases of all fins narrowly whitish. Under surface of head and belly somewhat pale.

Length 150 to 179 mm.

Fifteen examples from Ningkwo.

***Pseudorasbora parva* (Schlegel)**

Head contained $3\frac{1}{4}$ to $3\frac{7}{8}$ times in length to base of caudal; depth $3\frac{1}{3}$ to $4\frac{3}{5}$. Dorsal III, 7, I; anal III, 6, I. Scales 33 to 35 in lateral line to caudal base and 2 more on latter; 5 or 6 scales above lateral line, 4 to 6 below; 13 to 15 predorsal scales. Snout 3 to $3\frac{2}{5}$ in head; eye $3\frac{1}{8}$ to 5; maxillary $3\frac{7}{8}$ to 4; interorbital $2\frac{2}{5}$ to $2\frac{4}{5}$. Pharyngeal teeth 5—5, hooked, with grinding-surfaces; bones quite small. Scales with 2, 3 or 4 apical radiating striæ; circuli moderate.

Color in alcohol brownish generally, on back and upper sides each scale as if with median brownish blotch. All fins with more or less grayish to dusky terminally. Sometimes dark pigment spots concentrated along lateral line to form median lateral dark streak, resolving in dark spot just before caudal base. One example shows terminal portions of all fins, caudal broadly bordered so behind, with dusky to blackish, also sort of transverse or horizontal basal blackish band, as if made up of black pigment dots. Length 28 to 91 mm.

Hsing Lung Shan, August 7, 1921, 110 examples, and south of Hsing Lung Shan, August 12, 27 examples.

In the very young the front dorsal edge is blackish and there is a narrow blackish lateral band from side of snout to caudal base. It also has the lateral line very incomplete, only on the first few anterior scales. One young example is without mandibles, its jaws abortive, though both nostrils still in front of the eyes; or in profile what remains of the snout is less than half the eye.

For comparison with the Japanese specimens in the Academy, there is a series represented by many specimens from Yodo River in Osaka, Lake Biwa at Matsubara, Iwai River at Ichinoseki and near Nagoya in Owara. These show the following.

Head contained $3\frac{1}{8}$ to $4\frac{1}{8}$ times in length to base of caudal; depth $3\frac{1}{4}$ to 4. Dorsal III, 7, I; anal III, 6, I. Scales 29 to 36 in lateral line to caudal base and 2 or 3 more on latter; 5 or 6 scales above lateral line, 4 below; 12 to 15 predorsal scales. Snout $3\frac{1}{10}$ to $3\frac{1}{3}$ in head; eye $3\frac{2}{3}$ to $4\frac{3}{4}$; maxillary $3\frac{1}{5}$ to $4\frac{2}{3}$; interorbital $2\frac{1}{4}$ to $2\frac{1}{2}$. Pharyngeal teeth 5—5, rarely 1, 5—6.

Length 38 to 90 mm.

Rasborinæ

Aphyocypris chinensis Günther

Figure 1

Head contained $3\frac{7}{8}$ times in length to base of caudal; depth $3\frac{7}{8}$. Dorsal III, 7, I; anal III, 6, I. Scales 33 in lateral line to caudal base and 2 more on latter; 6 scales above lateral line, 4 below; 13 predorsal scales. Snout 3 times in head measured from upper jaw tip; eye 4; mouth width $3\frac{1}{3}$; interorbital $2\frac{1}{3}$.

Body compressed, fusiform, deepest at dorsal origin, edges convexly rounded. Caudal peduncle strongly compressed, least depth $1\frac{2}{3}$ times in its length or 2 in total length of head.

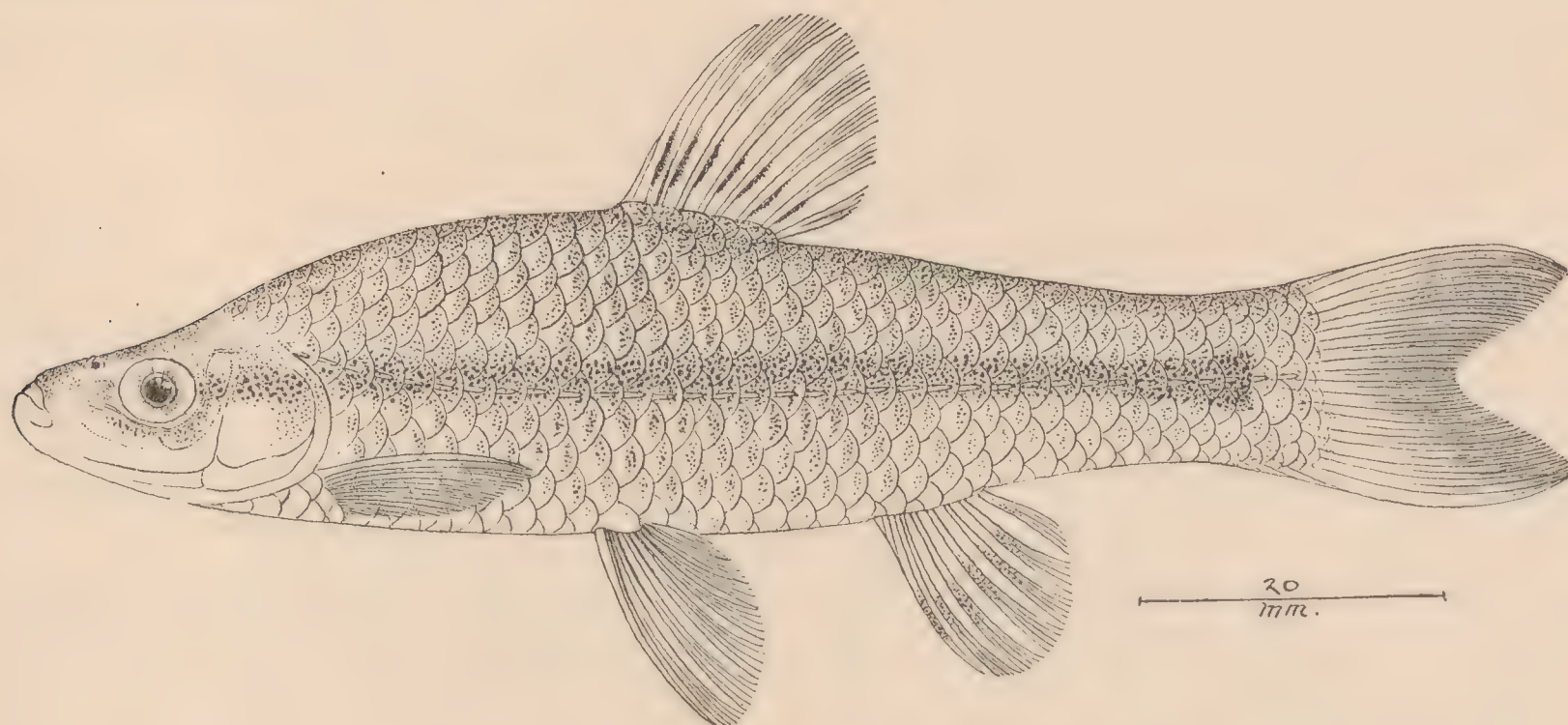


Fig. 1. *Aphyocypris chinensis* Günther. Ningkwo.

Head conic, upper profile slightly concave, flattened sides but little constricted below; width $1\frac{7}{8}$ in its total length. Snout conic, little depressed above, length $\frac{2}{3}$ its width. Eye with hind pupil edge midway in total head length; $1\frac{1}{3}$ times in snout, $1\frac{3}{4}$ in interorbital. Mouth superiorly terminal, greatly inclined, with short gape, mandible well protruded. Maxillary concealed, not reaching opposite nostril. Lips firmly coriaceous, lower broad and trenchant. Nostrils together, within last third of snout; front one a pore, with broad hind cutaneous flap exposing posterior nostril in crescent. Interorbital broadly convex. Suborbitals moderate, invade little over half of cheek to preopercle ridge. Opercle smooth.

Gill-opening extends forward to opposite last third of head. Gill-rakers 4+12, short points, rudimentary, greatly less than gill-filaments, which nearly equal eye. Pseudobranchiæ $\frac{2}{5}$ of gill-filaments. Pharyngeal teeth 3, 5—5, 3, hooked and with broad grinding-surfaces.

Scales with 33 to 36 waved radiating striæ apically; 32 to 36 basal circuli. Scales firmly adherent, in even longitudinal series, all well exposed, scarcely smaller on breast and caudal peduncle; axillary ventral scale $\frac{1}{4}$ the length of fin. Head naked. Lateral line extends along middle of side, complete; tubes extend over half of each scale exposure, slender, simple.

Dorsal origin midway between snout tip and caudal base, upper edge of fin convex; depressed fin reaches half way to caudal base. Anal inserted a little behind dorsal base, lower edge of fin convex; depressed fin reaches a distance contained $1\frac{3}{4}$ times in that to caudal base. Caudal deeply emarginate; lobes broad and pointed. Pectoral low, reaches $\frac{5}{6}$ to ventral. Ventral inserted slightly before dorsal origin, reaches $\frac{7}{8}$ to anal. Vent close before anal.

Color in alcohol, back dull olive-brown, each scale with darker submarginal blotch. Dusky streak from snout tip back from eye and along middle of side to caudal base, where expanded, much broader. Its entire course made up of dusky specks or dots. Lower surface of head and trunk whitish. Dorsal pale, a little below its middle, a short dusky bar close behind each ray. Median portion of each anal ray with slight gray-dusky shade. Caudal pale gray. Paired fins whitish. Iris silvery-white.

Length 100 mm.

One example from Ningkwo.

Xenocypridinæ

Xenocypris davidi Bleeker

Head contained $4\frac{1}{4}$ to $4\frac{1}{2}$ times in length to base of caudal; depth $3\frac{2}{3}$ to $3\frac{4}{5}$. Dorsal III, 7, 1; anal III, 10, 1 or 11, 1; pectoral I, 16 or 17; ventral I, 8. Scales 60 to 64 in lateral line to caudal base and 3 more on latter; 12 scales above lateral line, 7 below; 26 to 29 predorsal scales. Head width 2 to $2\frac{1}{10}$ in its length; head depth $1\frac{1}{3}$ to $1\frac{3}{5}$; snout $3\frac{1}{3}$ to $3\frac{1}{2}$; eye $3\frac{4}{5}$ to 4; maxillary $4\frac{3}{4}$; interorbital $2\frac{3}{4}$ to 3.

Body elongately ovoid, strongly compressed, deepest at dorsal origin, and edges all convexly rounded. Caudal peduncle strongly compressed, least depth $1\frac{2}{5}$ in its length, or 2 to $2\frac{1}{6}$ in head.

Head well compressed, flattened sides slightly approximated below, upper profile nearly straight to slightly convex, and lower profile similar to slightly more inclined. Snout convex, rather obtuse, length $\frac{3}{4}$ to $\frac{7}{8}$ its width. Eye moderate, hind edge slightly nearer gill-opening than snout tip; $1\frac{1}{8}$ in snout, $1\frac{1}{2}$ in interorbital. Mouth small, inferiorly terminal, width $1\frac{1}{8}$ to $1\frac{1}{4}$ in eye. Maxillary largely concealed by preorbital, at least its expansion, which 4 in eye, reaches opposite front nostril. Lips moderate, entire. Edge of upper jaw firmly coriaceous. Nostrils together, front one at about last third in snout, pore-like, and hind one a crescentic slit close behind, formed by cutaneous marginal flap of anterior. Interorbital broadly and evenly convex. Suborbital chain moderate; preorbital depth about $\frac{4}{5}$ its length which $1\frac{1}{4}$ in eye. Opercle finely striate.

Gill-opening extends forward to opposite hind eye edge. Gill-rakers 12+40, short, thin, compressed, triangular, $\frac{1}{3}$ the length of gill-filaments, which $1\frac{2}{5}$ in eye. No pseudobranchiæ. Pharyngeal teeth 2, 4, 6—6, 4, 2, strongly compressed, without hooks, and all with grinding-surfaces, outer quite broad. Some teeth deciduous, as several loose ones of outer set to each base.

Scales with 12 apical radiating striæ, often 0 to 3 apical marginal auxiliaries; basal circuli 55 to 60. Scales in even longitudinal series parallel with lateral line, scarcely smaller on predorsal; slightly smaller scales on breast, belly and caudal base; pointed scaly flap in ventral axil $\frac{2}{5}$ the length of fin. Head naked. Lateral line complete, well decurved, passes lower $\frac{2}{5}$ in depth at ventrals and ascends along side of caudal peduncle to caudal base medially; tubes simple, extend over each scale about midway to $\frac{3}{4}$ of exposure.

Dorsal origin midway between snout tip and caudal base, first 3 rays spine-like, osseous, compressed and third greatly longest; first branched dorsal ray $1\frac{1}{8}$ to $1\frac{1}{6}$ in head; depressed fin reaches a distance contained $2\frac{1}{4}$ to $2\frac{1}{3}$ times in that to caudal base. Anal begins well behind depressed dorsal tip, first branched ray highest and forms apex of slight anterior lobe; first branched anal ray $1\frac{7}{8}$ to 2 in head. Caudal strongly forked, lobes sharply pointed, slender, equal, little longer than head. Pectoral reaches a distance contained $1\frac{1}{2}$ to $1\frac{2}{3}$ times in that to ventral, contained $1\frac{1}{4}$ in head. Ventral inserted opposite dorsal origin, reaches a distance contained $1\frac{3}{4}$ to $1\frac{4}{5}$ times in that to anal; $1\frac{2}{5}$ to $1\frac{1}{2}$ in head. Vent close before anal.

Color in alcohol with back tinged with pale olive, sides and lower surface pale to whitish. Dorsal and caudal pale olivaceous, lower fins whitish. Iris slaty and whitish.

Length 173 to 228 mm.

Six examples from Ningkwo.

Rhodeinæ

Acanthorhodeus guichenoti Bleeker

Head contained $3\frac{3}{4}$ to 4 times in length to base of caudal; depth 2 to $2\frac{1}{6}$. Dorsal III, 16, 1 to 18, 1; anal II, 11, 1 to 14, 1. Scales 34 or 35 in lateral line to caudal base and 3 or 4 more on latter; 6 or 7 scales above lateral line, 5 or 6 below; 14 or 15 predorsal scales. Snout $3\frac{1}{5}$ to $3\frac{1}{3}$ in head; eye $3\frac{2}{5}$ to $3\frac{1}{2}$; maxillary $3\frac{3}{4}$ to 4; interorbital 3.

Body strongly compressed, deeply ovoid, predorsal scarcely trenchant and all other edges rounded convexly; greatest depth at dorsal origin. Caudal peduncle well compressed, its least depth 1 to $1\frac{1}{8}$ in its length or 2 to $2\frac{1}{10}$ in head.

Head small, strongly compressed, sides flattened and scarcely approximated below; profiles similar; head width 2 to $2\frac{1}{8}$ in its length. Snout conic, short, obtuse, length $\frac{7}{8}$ its width. Eye advanced, hind pupil edge slightly before center in head length; diameter equals snout, $1\frac{1}{6}$ to $1\frac{1}{3}$ in interorbital; very narrow border of adipose tissue all around eye. Mouth slightly inclined, lower jaw a little the shorter. Maxillary largely concealed, reaches opposite hind nostril, and with short terminal barbel, not over $\frac{1}{3}$ of pupil in length. Edges of jaw firmly coriaceous and lips narrow. Nostrils together, within last fourth of snout; front one a simple pore, its hind cutaneous flap exposes hind nostril in crescent. Interorbital widely convex. Suborbital chain moderate; posterior infraorbital largely covering cheek.

Gill-opening extends forward to opposite hind edge of eye. Gill-rakers 2+5 short points, about $\frac{1}{6}$ the length of gill-filaments, which $1\frac{1}{4}$ in eye. Pseudobranchiæ $1\frac{1}{2}$ in gill-filaments. Pharyngeal teeth 5—5, compressed, each with slight terminal hook and lower face with strong crenulations, these more or less obsolete in smaller examples; each also with broad entire inner grinding-surface.

Scales with 55 to 61 fine waved weak apical marginal striæ; circuli fine, all basal. Scales closely adherent on trunk, thin, in longitudinal series, deepest medianly and

rows slightly convergent anteriorly and posteriorly; scales much smaller on breast. Basal scaly sheaths to dorsal and anal moderate and caudal base covered with moderate scales. Pointed axillary ventral scale $2\frac{1}{2}$ in fin. Lateral line complete, curves slightly inferiorly along side to caudal base medianly; tubes slender, simple, well exposed or at least half way in scale exposure. Male with front half of snout before nostrils with thick-set pits, evidently tubercle scars and not present in female.

Dorsal origin little nearer snout tip than caudal base; first 3 rays strongly osseous, compressed, though third with flexible tip; length of first branched ray $1\frac{1}{8}$ to $1\frac{1}{6}$ in head. Anal origin midway between gill-opening and caudal base, in younger specimens, a little advanced or midway between hind eye edge and caudal base; first 2 rays similarly osseous to those of dorsal and last soft rays greatly shorter in both, than front ones; first branched anal ray $1\frac{1}{5}$ to $1\frac{2}{5}$ in head. Caudal deeply forked, lobes pointed, equal; lower lobe $3\frac{1}{4}$ to $3\frac{3}{5}$ in combined head and trunk. Pectoral low, nearly or quite reaching ventral, $1\frac{1}{4}$ to $1\frac{2}{5}$ in head. Ventral inserted little before dorsal origin; depressed fin reaching $\frac{4}{5}$ to $\frac{7}{8}$ to anal; fin $1\frac{2}{5}$ to $1\frac{1}{2}$ in head. Vent opposite middle of depressed anal and anal papilla moderate in female, not extending beyond end of depressed ventral tips.

Color in alcohol pale brownish generally, back with slight grayish tinge. Close above lateral line about 4 to 6 scales each with an obsolete pale dusky spot, and along side of caudal peduncle a narrow slaty streak, also above lateral line and horizontally median in position. Fins all pale, dorsal, anal and caudal with 3 or 4 rows of obscure grayish spots. Pectoral and ventral uniform. Iris whitish.

Length 105 to 170 mm.

Fourteen examples from Ningkwo.

Acanthorhodeus hypselonotus Bleeker¹ apparently differs in its much deeper body, larger scales, fewer dorsal rays and the absence of barbels.

Abramidinæ

Chanodichthys bramula (Valenciennes)

Head contained 4 times in body to caudal base; depth $2\frac{1}{8}$. Dorsal III, 7, 1; anal III, 28, 1. Scales 50 in lateral line to caudal base and 3 more on latter; 12 scales above lateral line, 9 below; 28 predorsal scales. Snout $3\frac{1}{2}$ in head; eye $4\frac{1}{2}$; maxillary $3\frac{2}{3}$; interorbital $2\frac{1}{3}$.

Body strongly compressed, deeply ovate, predorsal slightly trenchant and post-ventral with distinct keel over which scales not passing; greatest depth at dorsal origin. Caudal peduncle strongly compressed, its length $\frac{3}{4}$ its least depth, which 2 in head.

Head small, profiles alike, that of occiput curving up suddenly and convexly to dorsal fin; flattened sides but slightly constricted below; width of head 2 in its length. Snout broad, conic, its length $\frac{2}{3}$ its width. Eye with center slightly behind first third of head; its diameter $1\frac{1}{5}$ in snout, 2 in interorbital. Mouth broad, with short gape, and closed jaws even. Maxillary concealed, reaches opposite hind nostril. No barbels. Both jaws with strong, trenchant, cartilaginous edges. Lips firm. Nostrils together, within last third of snout; hind one twice size of front one and exposed in crescent, due to hind cutaneous flap of front one. Interorbital broadly convex. Suborbital

¹1871, Verhandel. Kon. Akad. Wet. (Amsterdam), XII, (No. 2), p. 43, Pl. XI, fig. 2.

chain narrow, extends only over upper fourth of cheek. Opercle with finely radiating striæ.

Gill-opening extends forward opposite last $\frac{2}{5}$ in head. Gill-rakers 5+10, slender points, $\frac{1}{4}$ the length of gill-filaments, which $1\frac{1}{8}$ in that of eye. Pseudobranchiæ half length of gill-filaments. Pharyngeal teeth, 2, 4, 4—5, 4, 2, compressed, tips slightly hooked, grinding-surfaces slight and entire.

Scales with 21 to 29 apical striæ; basal circuli fine, 67. Scales closely adherent, thin, in even longitudinal series all more or less well exposed, but slightly larger about body edges and on breast; caudal base with little smaller scales. Ventral with pointed axillary scale, $\frac{1}{3}$ the length of fin. Lateral line slightly decurved, becomes median at caudal base; tubes simple, extend over half of each scale exposure.

Dorsal origin a little nearer caudal base than snout tip, first 3 rays osseous, entire, and third with flexible tip; depressed fin reaches a distance $1\frac{7}{8}$ in that to caudal base; first branched dorsal ray $1\frac{9}{10}$ in head. Anal origin opposite base of last dorsal ray, 3 times length of last; first branched ray $1\frac{9}{10}$ in head. Caudal deeply forked, lower lobe slightly longer, or $3\frac{1}{4}$ in combined head and trunk. Pectoral low, not quite reaching ventral, $1\frac{1}{4}$ in head. Ventral inserted well before dorsal origin, reaches vent, which close before anal; ventral $1\frac{2}{5}$ in head.

Color in alcohol with back pale olivaceous, sides and below paler. Each row of scales with median white streak. Fins pale, all slightly grayish submarginally, vertical ones with slight dusky edges.

Length 185 mm.

One from Ningkwo.

Culter erythropterus Basilewsky

Head contained $3\frac{3}{4}$ to $3\frac{4}{5}$ times in body to caudal base; depth $3\frac{3}{4}$ to $4\frac{2}{5}$. Dorsal III, 7, 1; anal III, 20, 1 to 25, 1; pectoral I, 14 or 15; ventral I, 8. Scales 62 to 70 in lateral line to caudal base and 4 or 5 more on latter; 14 to 16 scales above lateral line, 8 or 9 below; 44 or 45 predorsal scales. Snout $3\frac{1}{4}$ to 4 in head measured from upper jaw tip; eye $4\frac{1}{5}$ to $5\frac{3}{5}$; maxillary 3 to $3\frac{1}{8}$; interorbital $3\frac{1}{2}$ to $4\frac{1}{8}$.

Body elongately ovoid, strongly compressed, deepest at dorsal origin, edges all convexly rounded, except slight median postventral keel. Caudal peduncle strongly compressed, least depth $1\frac{1}{4}$ to $1\frac{1}{2}$ in its length or $2\frac{1}{2}$ to $2\frac{4}{5}$ in head.

Head well compressed, flattened sides sloping evenly above and below, upper profile slightly concave from snout to occiput; width of head $2\frac{1}{4}$ to $2\frac{3}{5}$ in its length, depth $1\frac{1}{2}$ to $1\frac{4}{5}$. Snout convex, profile slightly convex in front, its length $\frac{7}{8}$ its width. Eye moderate, hind edge about midway in total head length; diameter 1 to $1\frac{1}{2}$ in snout, $1\frac{1}{8}$ to $1\frac{3}{4}$ in interorbital. Mouth moderate, well inclined, lower jaw well protruding. Maxillary largely concealed above by preorbital, reaches eye, expansion $1\frac{2}{3}$ to $1\frac{3}{4}$ in eye. Lips firm, fleshy, lower much broader laterally. Nostrils together; front one about at last third of snout, a simple pore; hind one a crescentic slit close behind, bounded by cutaneous marginal flap of front one. Interorbital broadly convex. Suborbital chain moderate; preorbital little deeper than long and its length slightly greater than eye.

Gill-opening extends forward opposite eye center. Gill-rakers 5+16, lanceolate, equal gill-filaments in length, or $1\frac{2}{3}$ in that of eye. Pseudobranchiæ half length of gill-filaments. Pharyngeal teeth, 2, 4, 5—4, 4, 2, hooked and with slight narrow grinding-surfaces.

Scales with 6 to 8 apical radiating striæ and 10 or 11 marginal auxiliaries; basal circuli 91 to 96. Scales in even longitudinal series parallel with lateral line, slightly crowded and smaller on predorsal, belly, breast and caudal base. Pointed scaly flap in ventral axil about $\frac{1}{4}$ the length of fin. Lateral line complete, decurved moderately, passes ventral at lowest third in body depth and ascends caudal base medianly; tubes simple, slender, extend over each scale about midway in its exposure.

Dorsal origin a little nearer caudal base than snout tip, first 2 rays spine-like, osseous, and third greatly longest; depressed fin $2\frac{1}{3}$ in distance to caudal base; first branched ray $1\frac{1}{4}$ to $1\frac{2}{5}$ in head. Anal begins slightly before depressed dorsal tip, first branched ray highest and forms apex of moderate anterior lobe; $2\frac{1}{10}$ to $2\frac{2}{3}$ in head. Caudal strongly forked, lobes sharply pointed, slender and equal; lower lobe equals or little more than head. Pectoral reaches $\frac{2}{3}$ to ventral, $\frac{9}{10}$ in smaller examples; length $1\frac{1}{4}$ to $1\frac{2}{3}$ in head. Ventral inserted slightly before dorsal origin, reaches $\frac{2}{3}$ to $\frac{7}{8}$ to anal; length $1\frac{2}{5}$ to $1\frac{7}{8}$ in head. Vent close before anal.

Color in alcohol, back tinged with pale olive, sides and lower surface pale to whitish. Dorsal and caudal pale olivaceous, lower fins whitish. Iris slaty to whitish.

Length 226 to 266 mm.

Two examples from Ningkwo.

Leuciscinæ

Leuciscus brandti (Dybowski)

Head contained $3\frac{1}{4}$ to $3\frac{3}{4}$ times in length to base of caudal; depth $4\frac{1}{2}$ to $5\frac{1}{4}$. Dorsal II, 7, 1; anal III, 7, 1. Scales 80 to 90 in lateral line to caudal base and 1 to 4 more on latter; 16 to 20 scales above lateral line, 10 to 16 below; 52 to 60 predorsal scales. Snout $3\frac{1}{4}$ to $3\frac{7}{8}$ in head; eye $3\frac{1}{4}$ to 5; maxillary $2\frac{3}{4}$ to $3\frac{1}{8}$; interorbital 3 to $3\frac{3}{4}$. Pharyngeal teeth 2, 5—4, 2, latter rarely 5, 2, slender, slightly hooked, with grinding-surfaces.

Color in alcohol with back deep dusky brownish generally, with lower and under surfaces pale to whitish. An inconspicuous blackish horizontal line from just above origin of lateral line backward, but obsolete behind dorsal and marking dark color of back. Along middle of side, from about level with eye, broad band little narrower and becoming conspicuously black after dorsal and ventral to middle of caudal. Caudal base with conspicuous and prominent black blotch size of pupil, midway at caudal base and distinctly separated from dark lateral band. Whole side of body sprinkled with variably dusky to black dots, specks and spots. Dorsal and caudal pale brownish, also pectoral with slight tinge of same. Ventral and anal whitish. On head dark band as obsolete or slightly reflected.

Length 34 to 163 mm.

Sixty-five examples from Hsing Lung Shan, August 7, 1921. In three very young examples the lateral line is present only on a few anterior scales. Two also have the eye slightly greater in diameter than the snout length, while one has the breast finely scaled.

The short diagnosis of *Telestes brandtii*¹ Dybowski gives the developed anal rays as 8, a condition I find in only one specimen in my series.

¹1912, Faune Russie, Pisc., III (1), p. 155, Fig. 6.

Berg shows an example from the lower Amur region. In his diagnosis of the species he repeats Dybowski's formula, though his figure shows certainly nine branched anal rays. It also does not show the dark median lateral band, the conspicuous detached black basal caudal spot and the speckled or dusted pattern of dark dots, so conspicuous in my examples.

***Phoxinus lagowskii* Dybowski**

Head contained $3\frac{1}{2}$ to $3\frac{3}{4}$ times in length to base of caudal; depth $4\frac{1}{4}$ to $4\frac{7}{8}$. Dorsal II, 7, 1; anal III, 7, 1. Scales 71 to 73 in lateral line to caudal base and 3 or 4 more on latter; 16 to 19 scales above lateral line, 11 or 12 below; 46 or 47 predorsal scales. Snout $3\frac{1}{5}$ to $3\frac{1}{4}$ in head; eye 5 to $5\frac{2}{5}$; maxillary 3 to $3\frac{1}{8}$; interorbital $3\frac{1}{10}$ to $3\frac{1}{4}$. Pharyngeal teeth 2, 5—4, 1, compressed, ends hooked and grinding-surfaces present. Scales with 30 radiating marginal striæ, of which 18 or 19 basal; circuli coarse.

Color in alcohol dusky-brown on back and upper surfaces, finely speckled or mottled irregularly with dusky to blackish, though in no place forming a dark lateral band. Vertical blackish line, less than eye, at caudal base. Upper inner border of gill-opening blackish. Lips pale. Iris dull slaty. Dorsal and caudal grayish-brown, other fins paler to whitish.

Length 106 mm.

Two examples from Hsing Lung Shan, August 7, 1921.

My examples agree largely with the figure and account by Berg¹ as *Phoxinus lagowskii variegatus* (Günther). This Berg admitted to subspecific rank as the southern and Chinese representative of *Phoxinus lagowskii*. I find nothing, aside from the alleged deeper caudal peduncle of *variegatus*, to distinguish it.

A comparison of the four types of *Leuciscus costatus* Fowler,² shows them to be synonymous. A further study of them shows the following details.

Head contained $3\frac{3}{5}$ to $3\frac{9}{10}$ times in length to base of caudal; depth $4\frac{1}{10}$ to $4\frac{4}{5}$. Dorsal II, 7, 1; anal III, 7, 1. Scales 71 to 73 in lateral line to caudal base and 2 to 4 more on latter; 14 to 16 scales above lateral line, 8 or 9 below; 44 to 48 predorsal scales. Snout 3 to $3\frac{2}{5}$ in head; eye $3\frac{3}{5}$ to $4\frac{1}{3}$; maxillary 3 to $3\frac{1}{4}$; interorbital $2\frac{2}{3}$ to $2\frac{7}{8}$. Pharyngeal teeth 2, 5—5, 2, grinding-surfaces little developed. In all, as in the Hsing Lung Shan specimens, the lateral line is complete. There is also a faint trace of the dark or blackish vertical basal caudal bar as in Berg's figure of *Phoxinus lagowskii*.³

***Idus waleckii* Dybowski**

Head contained $3\frac{2}{3}$ to $4\frac{1}{10}$ times in length to base of caudal; depth $3\frac{3}{5}$ to 4. Dorsal III, 8, 1; anal III, 10, 1. Scales 44 to 47 in lateral line to caudal base and 2 or 3

¹1912, Faune Russie, Pisc., III, (1), p. 231, Fig. 13.

²1899, Proc. Acad. Nat. Sci. Phila., 1899, p. 180. Tan Lan Ho, tributary Shu Lan Ho, Sungari Basin in Eastern Mongolia.

³1912, Faune Russ., Pisc., III, (1) p. 228, Pl. I, fig. 8.

more on latter; 9 or 10 scales above lateral line, 5 below; 23? to 26 predorsal scales. Snout $3\frac{2}{5}$ in head; eye $4\frac{1}{5}$ to 5; maxillary 3 to $3\frac{3}{5}$; interorbital 3 to $3\frac{1}{5}$.

Body elongate, rather slender. Head width 2 in its length, scarcely constricted below. Snout rather short, convex, length $\frac{3}{5}$ its width. Eye at first $\frac{3}{8}$ of head. Mouth very oblique. Maxillary greatly inclined, reaches about to eye. Interorbital broadly crescentic. Gill-rakers 3+6 short points, about $\frac{1}{4}$ of gill-filaments, which $1\frac{1}{5}$ in eye. Pharyngeal teeth 3, 5—5, 3, hooked, with narrow grinding-surfaces. Scales with 4 or 5 apical radiating striæ; circuli fine, though doubly so basally. Scales on breast and preventral but little smaller than others. Lateral line complete, well decurved. Dorsal origin midway between eye center and caudal base. Anal origin well behind base of last dorsal ray. Caudal emarginate. Pectoral contained $1\frac{2}{5}$ times in head. Ventral inserted a trifle before dorsal origin; fin $1\frac{3}{4}$ in head.

Color in alcohol faded dull dusky-brown on back, with olive tinge. Sides and lower surface dull brassy. Under surface more or less uniform. Iris brownish, also fins.

Length 168 to 215 mm.

Described from the type of *Leuciscus farnumi* Fowler, in the Acad. Nat. Sci. Philadelphia from the Tore River, and two paratypes from Dalai Nor, all obtained in 1897.¹

***Opsariichthys uncirostris* (Schlegel)**

Head contained $3\frac{1}{4}$ to $3\frac{1}{3}$ times in length to caudal base; depth 4 to $4\frac{2}{5}$. Dorsal III, 7, 1; anal III, 9, 1. Scales 41 to 45 in lateral line to caudal base and 3 more on latter; 9 scales above lateral line, 5 below; 20 or 21 predorsal scales. Snout $3\frac{1}{3}$ to $3\frac{2}{3}$ in head; eye 3 to 5; maxillary 2 to $2\frac{1}{4}$; interorbital 3 to $3\frac{2}{5}$. Pharyngeal teeth with broad grinding-surfaces and small terminal hooks. Scales with 5 to 12 apical radiating striæ; circuli moderate, fine apically. Lateral line only on about 7 anterior scales in young.

Color in alcohol silvery white. Dorsal and caudal grayish, lower fins whitish. Jaws and lower side of head pale, like belly.

Length 32 to 134 mm.

Fifteen examples, from twenty-six miles south of the Hsing Lung Shan, August 12, 1921.

For comparison there are in the Academy two from the Tore River in Eastern Mongolia, and a series of Japanese specimens from the Yodo River in Osaka. They show:

Head contained $3\frac{1}{5}$ to $3\frac{1}{3}$ times in length to caudal base; depth 4 to 5. Dorsal III, 7, 1; anal III, 9, 1. Scales 40 to 48 in lateral line to caudal base and 2 or 3 more on latter; 8 to 10 scales above lateral line, 4 or 5 below; snout $3\frac{1}{8}$ to 4 in head; eye $3\frac{1}{8}$ to 4; maxillary 2 to $2\frac{1}{2}$; interorbital $3\frac{1}{8}$ to $4\frac{1}{8}$; pharyngeal teeth 2, 3, 5—5, 3, 2, vary 2, 3, 5—4, 3, 2 or 1, 4, 4—5, 4, 1 or 1, 4, 4—4, 4, 1.

Length 50 to 135 mm.

¹1899, Proc. Acad. Nat. Sci., Phila., 1899, p. 179.

Zacco platypus (Schlegel)

Head contained $3\frac{1}{4}$ to $3\frac{5}{6}$ times in length to caudal base; depth 4 to 5. Dorsal II, 7, I; anal III, 9, I. Scales 41 to 43 in lateral line to caudal base and 3 more on latter; 7 or 8 scales above lateral line, 3 or 4 below; 16 to 18 predorsal scales. Snout 3 to $3\frac{2}{3}$ in head; eye 3 to 4; maxillary $2\frac{4}{5}$ to 3; interorbital $2\frac{1}{2}$ to 3. Pharyngeal teeth 2, 4, 4—4, 4, 2, hooked, with grinding-surfaces. Scales with 11 to 20 apical radiating striæ; circuli largely coarse apically, become fine basally. Pearl organs of male, a row of small ones from nostrils to antero-supraorbital; row around front edge of snout, slightly doubled on each side; then a continuous series of 4 horizontally on preorbital; on suborbital chain, a row close below eye to postorbital inferiorly; a series of 7 on lower ridge of preopercle; scattered tubercles on upper part of opercle and along its front edge vertically; a double row along lower side of each mandibular; second, third and fourth anal rays each with row of small tubercles along outer face.

Color in alcohol largely dull olivaceous above, edge of each scale slightly darker. Muzzle, upper surface of head and chin largely with dusky-slate to blackish, pale in female or non-ornamented male. Male with dusky-slate broad lateral band, interrupted by a number of pale lines or bars extending up and intersecting with whitish color of belly. Membranes of dorsal and anal dusky to blackish. Caudal largely with dusky tinge, especially on outer median portion. Other examples, tuberculate, and with but slight dusky on fins, show pale or orange tinge on middle of front dorsal edge and upper part of pectoral medianly. Same on ventral fin and front half of anal.

Length 34 to 130 mm.

From Hsing Lung Shan, August 7, 1921, 114 examples; twenty-six miles to south of Hsing Lung Shan, August 12, 1921, 105 examples.

For comparison I examined the following series of Japanese examples in the Academy: Kinu River at Utsonomiya, Yodo River in Osaka, Chilongo River in Kurume, Yabe River at Funayado, Kawatana near Nagasaki and Tsuruga. They show:

Head contained $3\frac{1}{2}$ to 4 times in length to caudal base; depth $3\frac{1}{2}$ to $4\frac{1}{4}$. Dorsal II, 7, I; anal III, 8, I to 10, I. Scales 36 to 46 in lateral line to caudal base, and 2 or more on latter; 8 scales above lateral line, rarely 7, 4 below; 15 to 17 predorsal scales. Snout 3 to $3\frac{1}{3}$ in head; eye $2\frac{3}{4}$ to $4\frac{1}{2}$; maxillary $2\frac{1}{2}$ to $2\frac{7}{8}$; interorbital $2\frac{3}{4}$ to $3\frac{1}{8}$. Pharyngeal teeth 2, 4, 5—5, 4, 2, vary 1, 4, 5—5, 4, 1 or 2, 4, 4—5, 4, 2 or 2, 4, 5—4, 4, 2 or 1, 4, 5—4, 4, 1 or 2, 4, 4—4, 3, 1.

Length 57 to 144 mm.

Zacco platypus has not before been reported from Northeast Mongolia. In the American Museum series another more progressively ornamented male shows the series of lateral snout pearl-organs and those on the lower preopercle ridge fused as a ridge. The latter are greatly similar to Boulenger's figure of *Opsariichthys acanthogenys*. Further, there are small scattered pearl-organs on the scales along the anal base and under surface of the caudal peduncle. The lower rudimentary caudal rays are much covered with adipose tissue, abruptly ending forward and like basal portions of lower caudal rays also finely studded with tubercles.

Tubercles on the anal fin are present on the anterior or rudimentary rays, basal tubercle of fourth, fifth and sixth anal rays enlarged and at tips of fifth, sixth and seventh two or three small terminal tubercles on each side.

***Pseudaspius leptcephalus* (Pallas)**

Head contained $3\frac{1}{6}$ times in length to caudal base; depth $4\frac{3}{4}$. Dorsal III, 7, 1; anal III, 9, 1. Scales 91 in lateral line to caudal base and 6 more on latter; 16 scales above lateral line, 10 below; 52 predorsal scales. Snout $3\frac{2}{5}$ in head measured from upper jaw tip; eye $6\frac{1}{2}$; maxillary $3\frac{2}{5}$; interorbital $4\frac{2}{3}$.

Body elongate, well compressed, edges rounded, deepest at dorsal origin. Caudal peduncle compressed, least depth 3 in total head length. Head attenuate, compressed, flattened sides not convergent; width $2\frac{3}{4}$ in its length. Snout broadly convex, depressed, a trifle longer than wide. Eye slightly before first third in head length. Premaxillaries protractile forward. Maxillary not quite reaching to eye or but a trifle behind posterior nostril. Mandible depressed, protrudes, $2\frac{1}{2}$ in total head length. Nostrils at last third of snout, superior. Interorbital broadly convex. Pre-orbital $1\frac{2}{3}$ in snout, width $1\frac{4}{5}$ its length. Postorbital equals eye. Gill-rakers 3+6, short strong firm points, $2\frac{3}{4}$ in length of gill-filaments, latter $1\frac{1}{2}$ in eye. Pharyngeal teeth 2, 5—?, ?, with slight grinding-surfaces. Scales small, reduced and crowded on median preventral and breast, little smaller on median predorsal and caudal base. Pointed adnate scaly flap in ventral axil. Lateral line well decurved.

Dorsal origin midway between hind eye edge and caudal base, fin reaches half way to caudal base, first branched dorsal ray longest, $1\frac{2}{3}$ in head. Anal a little behind dorsal base, first branched ray 2 in head. Caudal deeply forked, pointed lobes evidently subequal, upper lobe $1\frac{1}{4}$ in head. Pectoral 3 in head. Ventral inserted a little before dorsal, nearer anal origin than pectoral origin, 2 in head.

Color in alcohol, dull uniform brownish, paler below. Fins and iris plain brown. Length 247 mm.

Described above from an example in the Academy obtained in the Tore River, a tributary of the Sungari.

***Chela nicholsi* Fowler**

Figure 2

Head contained $4\frac{2}{3}$ times in length to caudal base; depth $4\frac{2}{3}$. Dorsal III, 7, 1; anal III, 22, 1; pectoral I, 14; ventral I, 8. Scales 58 in lateral line to caudal base and 4 more on latter; 10 scales above lateral line, 3 below; 40 predorsal scales. Snout $3\frac{2}{3}$ in head measured from upper jaw tip; eye $3\frac{3}{4}$; maxillary 3; interorbital $4\frac{1}{3}$.

Length 152 mm.

Type in the American Museum and paratype noted above in the Acad. Nat. Sci. Philadelphia. These are the only examples known.

***Pseudobrama dumerili* Bleeker**

Head contained $4\frac{1}{2}$ times in length to caudal base; depth $3\frac{1}{4}$. Dorsal III, 7, 1; anal III, 9, 1; pectoral I, 14; ventral I, 8. Scales 44 in lateral line to caudal base and 3 more on latter; 9 scales above lateral line, 4 below to ventral origin, 6 below to anal origin; 20 predorsal scales. Snout 4 in head; eye $3\frac{1}{2}$; maxillary $5\frac{1}{3}$; interorbital $2\frac{4}{5}$.

Body moderately ovoid, strongly compressed, deepest at dorsal origin, post-ventral with slight median keel over which scales not passing and other edges all convexly rounded. Caudal peduncle strongly compressed, least depth $1\frac{1}{5}$ in its length or $1\frac{7}{8}$ in head.

Head well compressed, flattened sides slightly approximated below, upper profile slightly convex, lower more so; width 2 in its length, depth $1\frac{1}{4}$. Snout convex, rather obtuse, length $\frac{3}{5}$ its width. Eye rather large, hind edge midway in head length, diameter 1 in snout, $1\frac{1}{4}$ in interorbital. Mouth small, inferiorly terminal, width $1\frac{1}{3}$ in eye. Maxillary largely concealed by preorbital, at least its expansion, which $3\frac{4}{5}$ in eye, or reaches opposite front nostril. Lips moderate, entire. Edges of jaws firmly coriaceous. Nostrils together, front one at last third in snout, pore-like, and hind one a crescentic slit close behind, formed by cutaneous marginal flap of anterior. Interorbital broadly and evenly convex. Suborbital chain moderate, preorbital depth $\frac{4}{5}$ its length, which $1\frac{1}{3}$ in eye. Opercle smooth.

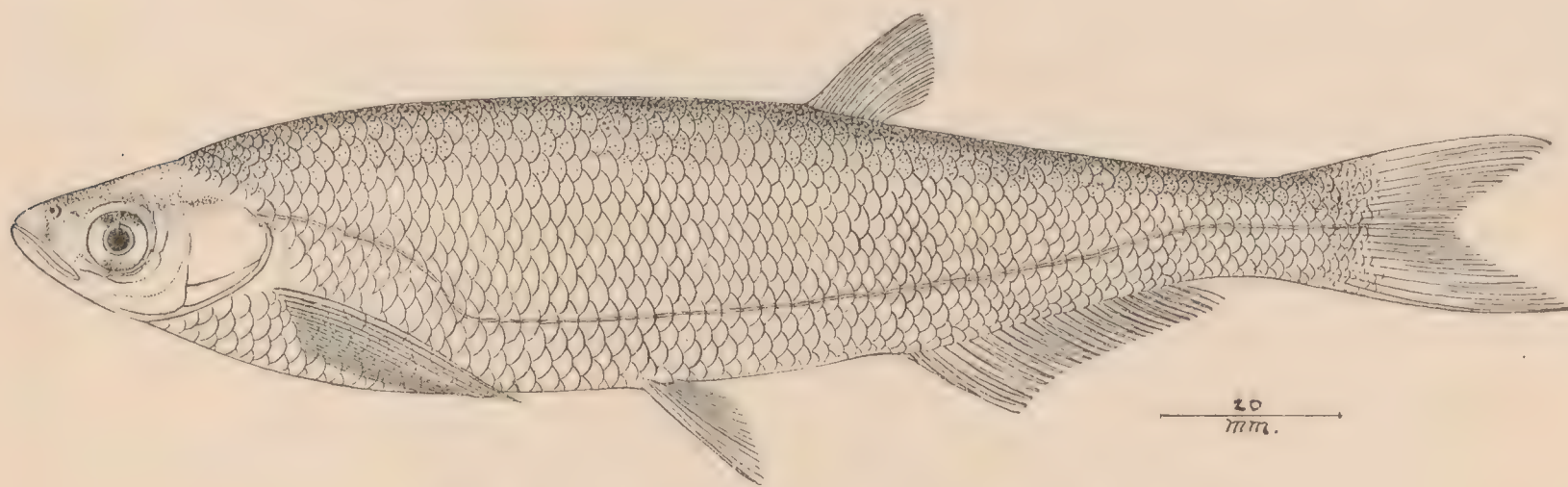


Fig. 2: *Chela nicholsi* Fowler. Type.

Gill-opening extends forward about opposite hind edge of eye. Gill-rakers 38+91, short, fine, slender, close-set, $2\frac{1}{8}$ in length of gill-filaments, which $1\frac{1}{2}$ in eye. No pseudobranchiæ. Pharyngeal teeth 6—7, strongly compressed, all with broad grinding-surfaces, and pointed but without hooks.

Scales with 16 to 19 apical radiating striæ, also 7 or 8 auxiliary marginals; basal circuli 45 to 60. Scales in even longitudinal series parallel with lateral line, scarcely smaller on breast and caudal base. Pointed scaly flap in ventral axil, about $\frac{2}{5}$ length of fin. Lateral line complete, deeply decurved, passes lower $\frac{2}{5}$ in body length at ventrals and ascends along side of caudal peduncle to caudal base medianly. Tubes simple, extend over each scale about midway of exposure.

Dorsal origin midway between snout tip and caudal base, first 3 rays spine-like, osseous, compressed, third greatly longest; first branched dorsal ray 1 in head. Anal begins well behind depressed dorsal, first branched ray highest and forms apex of slight anterior lobe, 2 in head. Caudal strongly forked, lobes sharply pointed, slender, equal, little longer than head. Pectoral reaches a distance contained $1\frac{1}{4}$ in that to ventral, $1\frac{1}{5}$ in head. Ventral inserted slightly before dorsal origin, reaches a distance contained $1\frac{7}{8}$ in that to anal, $1\frac{2}{5}$ in head. Vent close before anal.

Color in alcohol with back tinged pale olive, sides and lower surface pale to whitish. Dorsal and caudal pale olivaceous, lower fins whitish. Iris slaty and whitish. Length 170 mm.

One from Ningkwo.

Ochetobius elongatus (Kner)

Head contained $4\frac{3}{5}$ to $4\frac{7}{8}$ times in length to caudal base; depth $5\frac{1}{2}$ to $6\frac{2}{3}$. Dorsal III, 9, 1; anal III, 9, 1. Scales 63 to 65 in lateral line to caudal base and 3 more on latter; 10 or 11 scales above lateral line, 5 or 6 below; 28 to 30 predorsal scales. Snout $3\frac{2}{5}$ in head; eye $5\frac{1}{4}$ to 6; maxillary $3\frac{3}{5}$ to $3\frac{3}{4}$; interorbital $3\frac{1}{4}$ to $3\frac{2}{5}$.

Body greatly elongate, fusiform, compressed, deepest at dorsal origin, edges all convexly rounded. Caudal peduncle well compressed, its least depth 2 to $2\frac{1}{5}$ in its length or $2\frac{7}{8}$ to $3\frac{1}{10}$ in head.

Head small, compressed, its flattened sides slightly approximated below, upper profile nearly straight and much less inclined than lower; width of head $2\frac{1}{8}$ to $2\frac{1}{4}$ in its length. Snout conic, its length $\frac{7}{8}$ to 1 in its width. Eye center at first third in head; eye diameter $1\frac{2}{5}$ to $1\frac{3}{5}$ in snout, $1\frac{4}{5}$ in interorbital; adipose-lid moderate, invades a little more of eye behind than in front. Mouth oblique, closed jaws even in front. Maxillary reaches opposite hind nostril, largely concealed. Jaws firm and their edges rather trenchant. Nostrils together, within last fourth of snout; front one a pore, with hind cutaneous flap exposing posterior nostril in crescent. Interorbital broadly convex. Suborbitals narrow, cover but little of cheek, less than $\frac{1}{3}$ to preopercle ridge.

Gill-opening extends forward opposite hind eye edge. Gill-rakers 8+25, lanceolate, slender, contained $1\frac{1}{4}$ in the length of gill-filaments, or $1\frac{3}{5}$ in eye. Pseudo-branchiæ about half the length of gill-filaments. Pharyngeal teeth 2, 3, 5—5, 3, 2, with broad smooth grinding-surfaces but without terminal hooks.

Scales with 23 to 30 apical slightly waved radiating striæ; basal circuli fine. Scales largely adherent, thin, in even longitudinal series, largely uniform; scales a little smaller on breast and but slightly smaller on caudal base than on body. Ventral axillary scale $2\frac{1}{4}$ in the length of the fin. Lateral line complete, decurved slightly along side, and becomes median at caudal base. Tubes simple and extend about half way over scale exposure.

Dorsal origin slightly nearer snout tip than caudal base, first branched ray depressed reaches a little beyond tip of others, or is contained $1\frac{2}{5}$ to $1\frac{1}{2}$ in head; length of depressed fin contained $3\frac{1}{8}$ to $3\frac{1}{3}$ times in length to caudal base. Anal origin a little nearer last dorsal ray base than caudal base, first branched ray tip shorter than last when depressed, or $2\frac{1}{8}$ to $2\frac{1}{4}$ in head; depressed fin $1\frac{4}{5}$ to $1\frac{7}{8}$ times in distance to caudal base. Caudal deeply forked, lobes sharply pointed, alike, $4\frac{2}{5}$ to $4\frac{3}{4}$ in combined head and trunk. Pectoral reaches a distance contained $1\frac{9}{10}$ to $2\frac{1}{8}$ in that to ventral, $1\frac{1}{2}$ to $1\frac{3}{5}$ in head. Ventral inserted slightly before dorsal origin, $2\frac{1}{4}$ to $2\frac{1}{3}$ in distance to anal origin, $1\frac{2}{3}$ to $1\frac{3}{4}$ in head.

Color in alcohol with back olivaceous, sides and below pale brownish, with traces of whitish. Eye and under surface of head silvery-white. Dorsal and caudal pale brownish, paired fins and anal whitish.

Length 235 to 270 mm.

Five from Ningkwo.

COBITIDÆ**Misgurnus anguillicaudatus** (Cantor)

Head contained 5 to $6\frac{1}{3}$ times in length to caudal base; depth $7\frac{3}{4}$ to 9. Dorsal II, 7, 1; anal II, 6, 1. Scales 138 to 170 in lateral line to caudal base. Snout $2\frac{2}{3}$ to

$2\frac{7}{8}$ in head; eye $5\frac{4}{5}$ to $7\frac{1}{5}$; maxillary $3\frac{3}{4}$ to 4; interorbital $4\frac{7}{8}$ to $5\frac{1}{4}$. Scales with 36 to 38 radiating striæ in young, adult with 68 to 70; circuli fine.

Color in alcohol dull brownish, back darker and color of upper surface rather abruptly distinct from that of lower surface. Back and upper surface more or less distinctly spotted with darker everywhere, though spots more pronounced posteriorly, or above anal and on caudal peduncle. Spots on back and sides often arranged as 2 longitudinal dark lines. Dorsal pale brown, with about 4 horizontal bands of dusky spots. Caudal with about 10 transverse vertical dusky spots and black blotch at base above nearly large as eye. Anal pale, also with few dusky spots.

Length 66 to 206 mm.

Eighty examples from Hsing Lung Shan and two from twenty-six miles south of Hsing Lung Shan, latter August 12, 1921. Besides these I have also included three from Tan lan Ho, in the Academy.

The color is variable, though always with a black spot at the bases of the upper caudal rays. Head and trunk always with scattered spots, specks or dots, variously close-set or more or less scattered. Sometimes only large scattered blotches to several times size of eye present, or larger blotches may occur only above lateral line. None show so great development of adipose-like rudimentary caudal rays as in the next species.

***Misgurnus decemcirrosus* (Basilewsky)**

Figure 3

Head contained 5 to $5\frac{3}{4}$ times in length to base of caudal; depth 6 to $6\frac{7}{8}$. Dorsal II, 7, I, sometimes 8, I; anal II, 6, I, sometimes 5, I. Scales 95 to 127 in lateral line to caudal base. Snout $2\frac{1}{2}$ to $2\frac{3}{5}$ in head; eye 5 to $7\frac{1}{4}$; maxillary 4 to $4\frac{1}{3}$; interorbital $3\frac{3}{4}$ to $6\frac{3}{4}$. Scales with 36 to 44 radiating striæ in young, with circuli about 70 rows; adults with 77 to 80 radiating striæ.

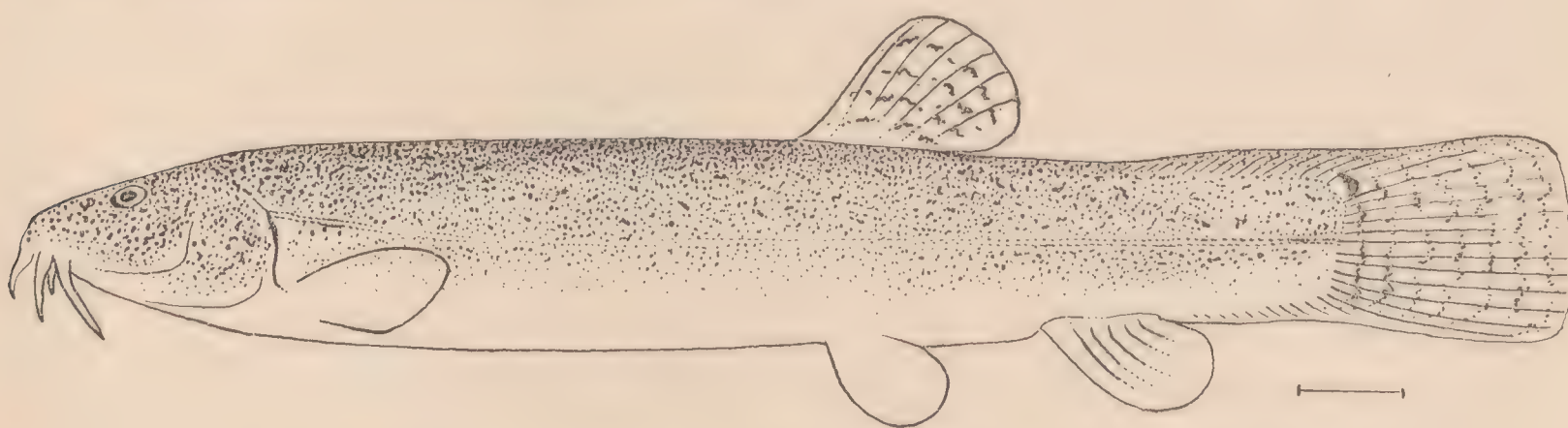


Fig. 3. *Misgurnus decemcirrosus* (Basilewsky). Tien Tsen.

Color in alcohol dull brown, finely specked or dotted with dusky on back and upper surface. Obscure dusky or blackish spot at bases of upper caudal rays not much larger than pupil.

Length 132 to 196 mm.

Six from Ningkwo. Also twenty-one from the Pietto River at Tien Tsen collected by N. F. Drake, in the Academy.

The Ningkwo examples are all with very great development of the rudimentary caudal rays, starting close behind the dorsal base in most cases and joining behind with the caudal. Lower rudimentary caudal rays likewise greatly developed, begin close behind anal base and fused posteriorly with caudal.

Color pattern also very variable, as some with large scattered dusky to blackish spots on head and trunk, though none much larger than eye. Body similarly finely sprinkled with dark dots, specks or small spots as in *Misgurnus anguillicaudatus*.

Misgurnus crossochilus Sauvage is doubtless a synonym. The details set forth in the original description do not show any characters worthy of specific value and agree so far as given with my materials of the present species.

***Nemacheilus toni* (Dybowski)**

Head contained 4 to $4\frac{2}{5}$ times in length to caudal base; depth $6\frac{7}{8}$ to $8\frac{3}{4}$. Dorsal II, 7, I or 8, I; anal II, 5. Scales quite minute, about half a millimeter in size and 128 to 140 estimated in lateral count; each with 30 radiating marginal striæ; circuli moderately fine. Snout $2\frac{1}{5}$ to $2\frac{2}{5}$ in head; eye $5\frac{3}{5}$ to $6\frac{7}{8}$; maxillary $3\frac{1}{4}$ to $4\frac{1}{5}$; interorbital $4\frac{1}{2}$ to $5\frac{3}{4}$.

Color in alcohol pale olive-gray on back to paler or whitish below, side and back with many large dull dusky blotches, rather irregular and most much larger than eye. Obscure dusky streak from side of snout to nostrils. Dorsal with about 4 and caudal with 5 or 6 cross bands made up of dusky blotches, fins otherwise pale to whitish. Several grayish blotches on pectoral medianly and anal terminally. In young example color-pattern much more contrasted. The markings appear variable in preserved examples as in the one in best condition they are as a row of large blackish blotches above and another below lateral line.

Length 60 to 99 mm.

Three from Hsing Lung Shan.

The type of *Nemachilus pechiliensis* Fowler, in the Academy, is now in such poor preservation that it is useless for examination. The original description, however, shows that it is clearly a synonym.

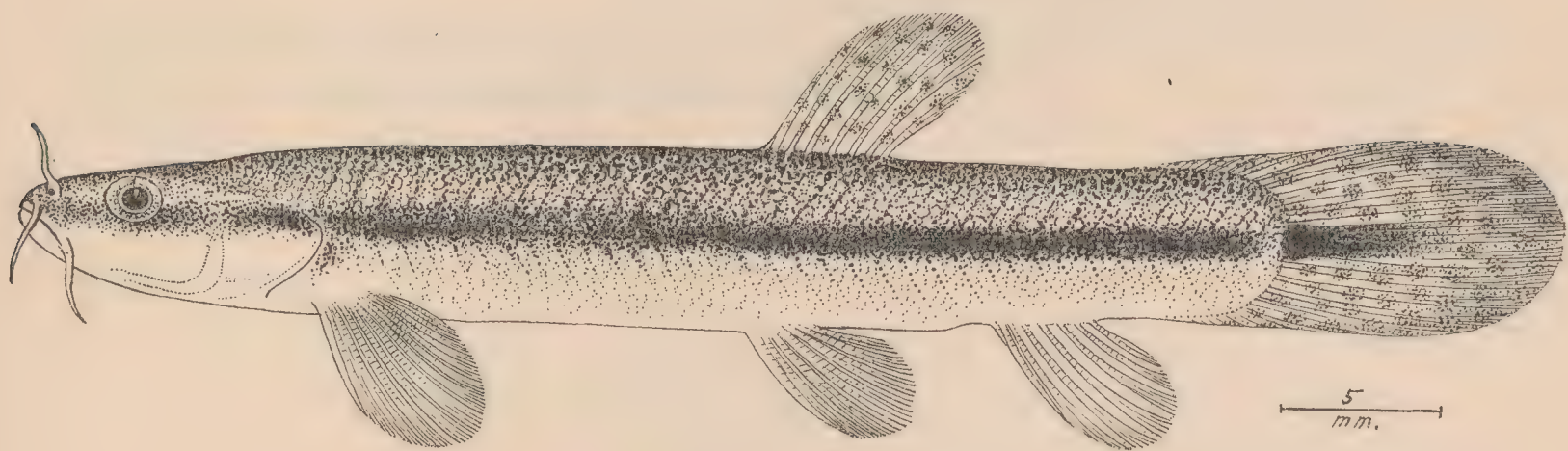
Orthrias oreas Jordan and Fowler¹ is also in agreement and is another synonym.

***Lefua andrewsi* Fowler**

Figure 4

Known only from the type in the American Museum.

¹1903, Proc. U. S. Nat. Mus., XXVI, p. 796, Fig. 2.

Fig. 4. *Lefua andrewsi* Fowler. Type.***Lefua costata* (Kessler)**

Head contained 4 to $4\frac{2}{5}$ times in length to caudal base; depth $6\frac{1}{6}$ to $6\frac{1}{2}$. Dorsal II, 6, I; anal II, 5, I. Scales 93 to 102 in median lateral series. Snout $2\frac{7}{8}$ to $3\frac{1}{8}$ in head; eye $4\frac{2}{5}$ to $6\frac{1}{4}$; maxillary $3\frac{3}{4}$ to $4\frac{1}{5}$; interorbital 3 to $3\frac{1}{3}$. Scales with 38 to 43 radiating marginal striae (30 to 36 in type of *Nemachilus dixonii*); circuli rather fine, moderate.

Color in alcohol brownish generally, with slight olive tint. Back and sides with very obscure scattered moderate spots of small size. Dorsal and caudal finely and obscurely spotted with gray-brown, though latter fin always with distinct round black spot at middle of base, not larger than pupil. Iris dull slaty, lips and jaws all pale or dull. Dark median lateral streak not very distinct and largely evident only after ventral.

Length 40 to 73 mm.

Six from Hsing Lung Shan.

In the Academy the type of *Nemachilus dixonii*, a synonym of the present species, is included above.

Elxis nikkonis Jordan and Fowler¹ is certainly closely related, though the alleged larger scales, given as about fifty-six, would seem to warrant specific distinction. It is, however, otherwise closely related, as the black basal caudal spot suggests.

Lefua echigonia Jordan and Richardson² is based on three young examples only 38 to 45 mm. long. It is represented with four barbels in profile, showing it doubtless had eight. Its coloration greatly suggests *Misgurnus decemcirrosus* (Basilewsky).

Nemachilus variegatus (Dabry) Sauvage and de Thiersant³ is probably a *Lefua*. It is described as having large brownish cloudings formed into a series of somewhat undulate bands and a black band at caudal and dorsal base.

¹1903, Proc. U. S. Nat. Mus., XXVI, p. 768, Fig. 1.

²1908, Proc. U. S. Nat. Mus., XXXIII, p. 263, Fig. 1.

³1874, Ann. Sci. Nat. Zool., I (2), p. 14.

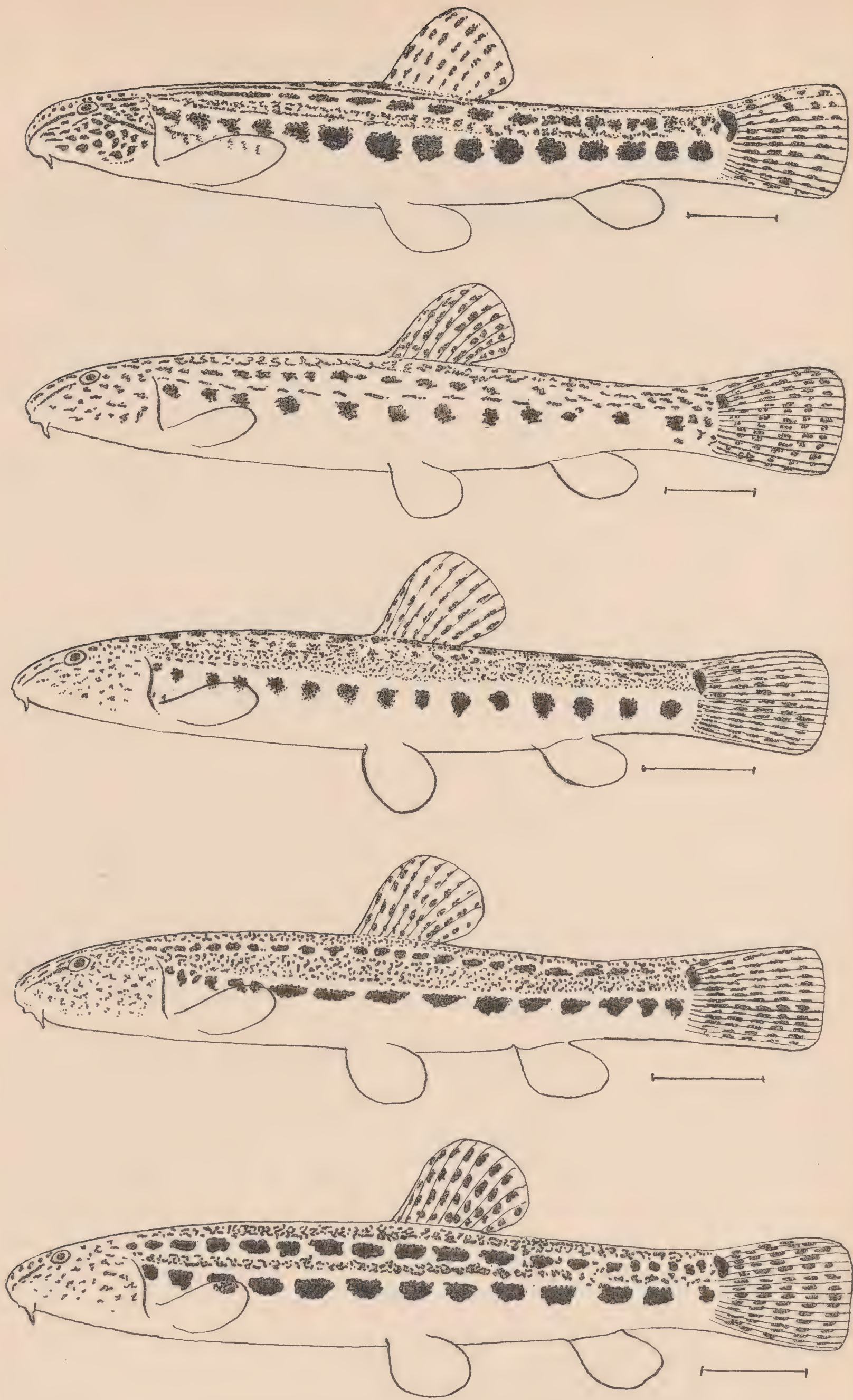


Fig. 5. *Cobitis taenia* Linnæus. Variation in color-pattern.

Cobitis tænia Linnæus

Figure 5

Head contained $4\frac{3}{4}$ to $5\frac{7}{8}$ times in length to caudal base; depth $6\frac{1}{3}$ to $7\frac{3}{4}$. Dorsal II, 6, I to 8, I; anal III, 4, I to 6, I. Snout $2\frac{1}{4}$ to $2\frac{3}{5}$ in head; eye $5\frac{1}{3}$ to $6\frac{1}{3}$; maxillary $3\frac{1}{3}$ to $4\frac{1}{3}$; interorbital 8 to $8\frac{2}{3}$.

Length 55 to 98 mm.

From Hsing Lung Shan, August 7, 1921, 83 examples.

In the Academy a series of 20 examples from Europe, the Italian Lakes and Sweden. These show the following.

Head contained $4\frac{3}{4}$ to $5\frac{1}{3}$ times in length to caudal base; depth $5\frac{7}{8}$ to $7\frac{1}{4}$. Dorsal II, 7, I; anal III, 5, I or 6, I. Snout $2\frac{1}{4}$ to $2\frac{3}{4}$ in head; eye $4\frac{3}{4}$ to 6; maxillary $3\frac{7}{8}$ to $4\frac{1}{4}$; interorbital $7\frac{3}{4}$ to 9.

Length 48 to 95 mm.

The scales are most striate in the largest European examples, the radiating marginal striæ showing 38 to 48 and circuli in the largest in about 25 series. In a Japanese example, representative of the nominal *Cobitis biwæ* Jordan and Snyder, from Kiroshina, and in all the above Chinese examples examined, besides one I reported from the Academy collection as the nominal *Cobitis sinensis* Sauvage and De Thiersant taken in the Tan Lan Ho, the marginal radiating striæ are 28 to 31. In no way do they differ from the other Chinese examples examined.

Considerable variation in the color-pattern is noticed in this species, and for comparison I have placed a drawing of the largest European example at the top of the accompanying figure, the others representing the extremes found in the Hsing Lung Shan series.

From the description of *Cobitis dolichorhynchus* Nichols¹ I am inclined to consider it a variant. It is said to be more elongate than *Cobitis tænia*, though its depth is given as only 5.8. From the above details this depth is within the range of my European examples. The alleged longer snout also appears variable. I fail to find any other characters on which to separate the Futsing specimens.

Four examples also obtained at Ningkwo, 137 to 165 mm.

SILURIDÆ**Parasilurus asotus** (Pallas)

Head contained $3\frac{4}{5}$ to $4\frac{3}{4}$ times in length to caudal base; depth $5\frac{4}{5}$ to $6\frac{1}{5}$. Dorsal I, 5; anal II to V, 68 to 77. Snout $2\frac{7}{8}$ to $3\frac{1}{6}$ in head measured from tip of upper jaw; eye $4\frac{1}{2}$ to 9; maxillary $2\frac{1}{2}$ to $3\frac{1}{8}$; interorbital $2\frac{1}{5}$ to $2\frac{1}{4}$. Lower jaw well protruded. In young maxillary barbel extends back to middle of depressed dorsal, or well beyond depressed pectoral.

¹1916, Proc. Biol. Soc. Wash., XXXI, p. 16. Futsing, Fu-kien.

Color in alcohol nearly deep mouse-gray above, becoming deep olive-buff on under surface of head and belly, sides below all with pale smutty dusted appearance. About 17 or 18 vertical rows of very inconspicuous pale small spots on back, transversely down till level with lateral line. Also few similar pale spots on upper surface of head. Pectoral and ventral pale. Iris slaty. Maxillary barbel dusky above, pale below. Mental barbels pale, like chin.

Length 58 to 332 mm.

Eleven from Hsing Lung Shan, August 7, 1921 and two from Ningkwo.

PORCIDÆ

Pseudobagrus macropterus (Bleeker)

Head contained $4\frac{1}{2}$ times in length to caudal base; depth $8\frac{2}{3}$. Dorsal I, 7; anal v, 10; pectoral I, 9; ventral I, 5. Snout $2\frac{3}{4}$ in head; eye 7; maxillary 3; interorbital $3\frac{2}{3}$; mouth width $2\frac{1}{2}$.

Body slender, depressed forward, strongly compressed behind, deepest about middle of depressed pectoral. Caudal peduncle little free, strongly compressed, least depth about $2\frac{1}{4}$ in its length or $2\frac{2}{5}$ in head.

Head broadly depressed, flattened medianly above, sides convex, width $1\frac{1}{3}$ in its length, depth $2\frac{1}{6}$. Snout broadly depressed, length $\frac{3}{5}$ its width as measured across at front of eyes. Eye center falls about first $\frac{2}{5}$ in length of head, elevated, lids free; $2\frac{2}{3}$ in snout, 2 in interorbital. Mouth broadly transverse, lower jaw much the shorter. Teeth in broad villiform bands in jaws and continuous across vomer and palatines. Lips thick, fleshy, plicated. Maxillary barbel long, reaches dorsal origin; hind nasal barbel longer than eye, $1\frac{4}{5}$ in snout; outer mental barbel reaches gill-opening or $\frac{3}{4}$ to pectoral origin; inner mental 3 in head. Nostrils separated; front one with low cutaneous rim, closer to hind one than to snout edge; hind nostril about $\frac{2}{5}$ in snout profile. Interorbital level.

Gill-opening extends forward opposite eye center. Gill-rakers 8+13, lanceolate, $1\frac{1}{6}$ in gill-filaments, which $1\frac{1}{8}$ in eye. Isthmus wide, depressed, broadly triangular.

Skin smooth. Lateral line distinct, midway along side.

Dorsal origin about first third in combined head and trunk, third ray longest and edges of membranes slightly emarginate. Dorsal spine 2 in head. Adipose dorsal very long $2\frac{1}{6}$ in combined head and trunk. Anal small, first branched ray highest, inserted a little nearer caudal base than pectoral origin; first branched ray $2\frac{2}{5}$ in head. Caudal deeply forked, lobes rounded, hind edge deeply emarginate and lower lobe $1\frac{2}{5}$ in upper; length $1\frac{1}{10}$ in head. Pectoral rounded, reaches a distance contained $1\frac{4}{5}$ in that to ventral; spine $1\frac{7}{8}$ in head, flattened, 14 teeth along hind edge. Ventral insertion nearer snout tip than caudal base or close behind base of last dorsal ray, fin reaches a distance contained $1\frac{1}{2}$ in that to anal, length $1\frac{7}{8}$ in head.

Color in alcohol pale slaty-gray above, with obscure slightly darker slaty dots scattered about, also on dorsals and caudal. Under surface of body pale to whitish. Maxillary and nasal barbels slaty, others whitish. Iris slaty.

Length 345 mm.

One from Ningkwo.

***Pseudobagrus fulvi-draco* (Richardson)**

Head contained $2\frac{3}{4}$ to $3\frac{3}{4}$ times in length to caudal base; depth 3 to $3\frac{3}{4}$. Dorsal I, 7, 1; anal, v, 15 or 16. Snout 3 in head; eye 4 to 7; maxillary $2\frac{3}{4}$ to 3; interorbital $2\frac{1}{5}$ to $2\frac{1}{2}$. Maxillary barbel extends back but little beyond head, though sometimes quite a little shorter. Serræ on hind edge of pectoral spine 14 to 16 and much more developed than the fine and more numerous even small denticles along front edge of spine. Dorsal spine often with very obsolete similar armature, or the denticles or spinules absent.

Color in alcohol slaty-brown above, with about 3 large obsolete blotches on side, well contrasted from same color of back above. In many color faded more or less brownish. All fins with more or less blackish blotch terminally, though on caudal in middle of each lobe. In young color-pattern greatly contrasted as blackish and very pale brownish.

Length 27 to 170 mm.

Ten from Hsing Lung Shan, August 7.

Pseudobagrus emarginatus Sowerby¹ is based on an example 413 mm. long without caudal. Sowerby says it is very much more elongate than *Pseudobagrus ussuriensis* (Dybowski), and closely resembles it except in its emarginate caudal. *Pseudobagrus ussuriensis* is said in the original description to reach 1000 mm., and to have a rounded caudal. Possibly this may be a condition with advanced age.

OPHICEPHALIDÆ***Ophicephalus argus* Cantor**

Head contained $2\frac{2}{3}$ to 3 times in length to caudal base; depth 5 to $5\frac{2}{3}$. Dorsal 48 to 51; anal 32 or 33. Scales 59 to 62 in lateral line to caudal base and 3 or 4 more on latter; 8 to 10 scales above lateral line, 13 to 15 below; 29 to 30 predorsal scales. Snout $5\frac{7}{8}$ to 6 in head measured from upper jaw tip; eye $5\frac{1}{5}$ to $7\frac{4}{5}$; maxillary $2\frac{2}{5}$ to $2\frac{3}{5}$; interorbital $4\frac{1}{5}$ to $5\frac{1}{2}$.

Body moderately long, compressed. Least depth of caudal peduncle $3\frac{2}{5}$ to $3\frac{4}{5}$ in total head length.

Head width $2\frac{1}{5}$ to $2\frac{1}{3}$ in its length. Hind pupil edge at first fourth in head; hind eye edge about first third in head in young; diameter 1 to $1\frac{1}{4}$ in snout, $1\frac{1}{6}$ to $1\frac{1}{3}$ in interorbital. Mouth large, lower jaw protruding. Maxillary extends well beyond eye, but slightly beyond in young. Teeth finely conic, in narrow bands in jaws; inner row along each side of mandible and row on vomer and palatines enlarged. Front nostril in short tube at first $\frac{2}{5}$ in snout; hind one a simple pore close above and before front eye edge. Interorbital depressed, level.

Gill-rakers 3+6, short low tubercles, largest slightly less than gill-filaments, which 2 in eye.

Scales with 9 to 18 basal marginal radiating striæ, 12 to 15 apical circuli, other circuli fine. Head with muzzle and jaws naked; 12 to 15 scales on cheek to preopercle edge; occipital scales scarcely larger than those on sides of head; small scales on

¹1921, Proc. U. S. Nat. Mus., LX, p. 1, Yalu River, Southern Manchuria.

breast and caudal basally. Lateral line a little high at first, drops 2 scales a little behind pectoral, then median to caudal base; tubes narrow and simple.

Median dorsal rays $3\frac{3}{5}$ to $3\frac{2}{3}$ in head; median anal rays $3\frac{1}{4}$ to $3\frac{3}{4}$; caudal rounded, $1\frac{3}{5}$ to $1\frac{2}{3}$; pectoral $2\frac{1}{2}$ to $3\frac{1}{2}$ (?); ventral $3\frac{1}{8}$ to $3\frac{1}{4}$.

Color in alcohol brown, paler below to whitish on under surface of head. Brown streak from side of snout to eye, then back along upper side of head to shoulder; another parallel from lower eye edge to pectoral base. Jaws and lower side of head with some pale brown spots. Pores along preopercle flange and mandible dusky. Trunk with row of 11 dark large rings, beginning at shoulder and continued above median axis to caudal base. Below median axis nearly equal number of less regular dark blotches, some angular or giving off slight oblique bars below, but all similarly with more or less dark bordering line. Vertical fins dusky terminally, with dark blotches. Pectoral pale brown, with dusky spot less than eye at bases of upper rays. Ventral whitish. Iris brown.

Length 98 to 222 mm.

Seven from Ningkwo.

Channa ocellata Peters

Head contained $3\frac{1}{6}$ to $3\frac{2}{3}$ times in length to caudal base; depth $4\frac{2}{3}$ to $5\frac{7}{8}$. Dorsal 43 to 48; anal 27 to 32. Scales 55 to 60 in lateral line to caudal base; 7 or 8 scales above lateral line, 14 or 15 below; 20 to 28 predorsal scales. Snout $3\frac{1}{4}$ to $4\frac{3}{4}$ in head measured from upper jaw tip; eye $5\frac{1}{3}$ to $7\frac{1}{8}$; maxillary $2\frac{1}{4}$ to $2\frac{1}{2}$; interorbital $3\frac{3}{5}$ to $3\frac{3}{4}$.

Body elongate, compressed. Least depth of caudal peduncle $2\frac{3}{4}$ to 3 in total head length.

Head width $1\frac{3}{5}$ to $1\frac{4}{5}$ in its length. Snout depressed, its length $\frac{2}{5}$ to $\frac{1}{2}$ its width. Eye center at first fourth in head, a little backward in young; diameter 1 to $1\frac{1}{2}$ in snout, $1\frac{1}{3}$ to $2\frac{1}{5}$ in interorbital. Mouth large, lower jaw slightly protruding. Mouth extends a little beyond eye, to hind eye edge in young. Teeth fine, simple, conic, in bands in jaws and on vomer and palatine; inner series of teeth in lower jaw enlarged, widely spaced. Lips fleshy, rather narrow. Front nostril in short tube on side of snout, $1\frac{4}{5}$ in eye; hind nostril elevated, opposite upper front eye edge. Interorbital broadly convex.

Gill-rakers as 5 tubercles, lower longer, all much shorter than gill-filaments, which $1\frac{2}{3}$ in eye.

Scales with 19 to 30 basal parallel striæ; apical circuli 10, giving place with age to about 35 irregular marginal striæ. Front half of snout, mandible and branchiostegal region naked, and scales on top of head largest, much larger than those on cheek; 9 rows of scales across cheek to preopercle edge. Most of pectoral and caudal finely scaled. Lateral line high anteriorly, after seventeenth scale dropping 2 scales, when midway to caudal base; tubes simple, small and with small pore.

Median dorsal rays 2 to $2\frac{4}{5}$ in total head length; median anal rays $2\frac{7}{8}$ to $3\frac{1}{2}$; caudal rounded behind, $1\frac{1}{8}$ to $1\frac{1}{4}$; pectoral $1\frac{3}{5}$ to $1\frac{3}{4}$, reaches a distance contained $1\frac{1}{5}$ to $1\frac{1}{3}$ in that to vent.

Color in alcohol brown on back, paler to livid whitish on under surface of head and trunk. Dark streak from upper hind eye edge back toward middle of opercle, lower one from lower hind eye edge back toward pectoral base. Lower jaw neutral tint, with dusky line on and along upper maxillary edge and another on side of

mandible close along edge of lower lip. In young, lower side of head more or less distinctly spotted with brown. Trunk with 10 dusky to blackish large median blotches. First as large black round spot above pectoral axil and last as larger round black spot at caudal base, which mostly above lateral line and its edge narrowly pale. With age most of entire body finely spotted with pale or whitish, sometimes 2 spots on 1 scale. Dorsal and anal neutral-dusky, former usually with scattered small whitish spots. Pectoral and caudal brownish.

Length 93 to 255 mm.

Thirteen from Ningkwo.

SERRANIDÆ

Siniperca chuatsi (Basilewsky)

Head contained $2\frac{1}{4}$ to $2\frac{2}{3}$ times in length to caudal base; depth $2\frac{7}{8}$ to $3\frac{2}{3}$. Dorsal XII, 12 to 14; anal III, 8 to 10. Scales 128 to 130 counted along lateral line to caudal base; pores 115 in lateral line to caudal base; 20 scales above highest arch of lateral line to spinous dorsal base, 38 below to spinous anal origin; 33 ? predorsal scales. Snout $3\frac{1}{8}$ to 4 in head measured from upper jaw tip; eye 5 to $5\frac{1}{2}$; maxillary 2 to $2\frac{1}{6}$; interorbital $5\frac{2}{3}$ to 7.

Body elongately fusiform, well compressed. Least depth of caudal peduncle $1\frac{1}{5}$ to $1\frac{1}{3}$ in its length to $3\frac{1}{2}$ to $4\frac{1}{5}$ in total head length.

Head width $2\frac{1}{2}$ to $3\frac{3}{4}$ in its length, much more attenuated in young. Snout conic, width $1\frac{1}{8}$ to $1\frac{1}{6}$ in its length. Hind edge of eye midway in length of head, diameter $1\frac{1}{8}$ to $1\frac{2}{3}$ in snout, $\frac{3}{5}$ to 1 in interorbital. Mouth moderate, mandible protruding, greatly so in young. Maxillary extends slightly beyond hind eye edge, opposite hind pupil edge in young; expansion $1\frac{2}{3}$ in eye. Teeth moderately fine, conic, 4 or 5 series in front above narrowing in 1 series on side posteriorly, 2 or 3 innermost each side of median line largest and directed inward; mandibulars 5 or 6 rows in front, narrowing to single outer low series with large inner row of 4 on each side; patch of small conic teeth on vomer and each palatine, none on tongue. Nostrils together, within last fourth of snout. Interorbital broadly depressed, level in young. Hind preopercle edge denticulate and 3 large denticles at angle, much larger in young.

Gill-rakers 1+3, lanceolate, $1\frac{1}{3}$ in gill-filaments, which $1\frac{2}{5}$ in eye.

Scales with 9 basal parallel striæ marginally; circuli 7 to 14 apically.

Fifth dorsal spine $2\frac{2}{3}$ to 4 in total length of head; eighth dorsal ray $2\frac{3}{4}$ to 3; second anal spine $3\frac{1}{6}$ to $3\frac{7}{8}$; second anal ray $2\frac{2}{5}$ to 3; caudal rounded behind, $1\frac{9}{10}$ to 2; pectoral $2\frac{1}{8}$ to $2\frac{2}{5}$; ventral $2\frac{1}{8}$ to $2\frac{1}{5}$.

Color in alcohol brown generally, little paler below. Trunk and head with more or less rounded close-set darker to dusky blotches or spots, some ring-like and small spots, dots, bars or short lines in paler areas. On head usually dark underlaid streak from behind eye back across postocular and another from lower hind eye edge. Jaws usually with obscure brownish blotches. In young markings on trunk usually reduced to large dark blotches, in very young forming about 6 dark vertical transverse bands, much wider than pale interspaces. Vertical fins pale, finely spotted with dark brown, spots fewer and larger in young, absent or little evident in very young. Pectoral pale. Ventral pale basally, little dusky sub-terminally.

Length 72 to 225 mm.

Nine from Ningkwo.

GOBIIDÆ

Eleotris potamophila Günther

Head contained $2\frac{3}{5}$ times in length to caudal base; depth $4\frac{1}{8}$ to $4\frac{2}{3}$. Dorsal VI to VIII—I, 8, 1 or 9, 1; anal I, 7, 1. Scales 40 to 45 in median lateral series to caudal base and 4 or 5 more on latter; transversely at soft dorsal origin 13 to 15 scales; 30 to 35 predorsal scales. Snout $3\frac{3}{4}$ to $4\frac{1}{4}$ in head measured from upper jaw tip; eye $5\frac{2}{5}$ to $7\frac{2}{5}$; maxillary $2\frac{1}{3}$ to $2\frac{1}{2}$; interorbital $3\frac{1}{5}$ to $5\frac{1}{3}$.

Body robust, subcylindrical, trunk more or less compressed posteriorly, deepest about dorsal origin. Caudal peduncle well compressed, least depth $1\frac{3}{4}$ to $1\frac{4}{5}$ its length or $3\frac{1}{10}$ to $3\frac{1}{4}$ in total head length.

Head robust, depressed, width $1\frac{3}{5}$ to 2 in its length. Snout broad, surface convex, length $\frac{3}{5}$ to $\frac{3}{4}$ its width. Eye slightly impinging on upper profile, center at first third in head; front pupil edge about first third in young; diameter $1\frac{1}{3}$ to 2 in snout, 1 to $2\frac{1}{5}$ in interorbital. Mouth large, wide, mandible well protruded. Maxillary reaches opposite hind pupil edge, about to eye center in young; expansion $1\frac{1}{4}$ to 2 in eye. Lips firm. Teeth simple, conic, moderate, large, in bands of 3 or 4 irregular series in jaws; none on vomer, palatines or tongue. Tongue broad, slightly convex along entire front edge. Front nostril in small short tube, at last $\frac{2}{5}$ in snout; hind nostril a simple pore, midway between front nostril and eye. Interorbital broadly and slightly depressed concavely. Preopercle entire, without spine.

Gill-rakers 3+8 or 9, spinescent tubercles, greatly shorter than gill-filaments, which equal eye.

Scales with 10 to 25 basal radiating striæ; apical denticles 65 to 70, and 2 or 3 series transversely; circuli fine. Jaws, snout, preorbital and under surface of head naked. Supraorbital with row of fine papillæ and above short series opposite nostrils; another row from close below eye up over postocular and suprascapula; double row along preopercle edge and continued forward along lower face of mandible to symphysis; small cluster of papillæ above maxillary on snout edge, also above front of supraorbital row; another cluster just below nostrils; infraorbital row begins just below hind nostril, slopes down toward maxillary, then abruptly up toward hind eye edge, where forking sends horizontal row back across cheek; below and parallel another midway on cheek, also small bar between posteriorly and anteriorly downward extension above upper maxillary edge; row down along front part of opercle closely parallel with preopercle edge. Breast and belly covered with small cycloid scales; about 17 scales across cheek to preopercle edge; caudal and pectoral bases finely scaly.

Third dorsal spine $2\frac{4}{5}$ to 3 in total length of head; third dorsal ray $2\frac{1}{4}$ to $2\frac{2}{5}$; second anal ray $2\frac{1}{2}$ to $2\frac{3}{5}$; caudal rounded behind, $1\frac{1}{3}$ to $1\frac{2}{5}$; pectoral $1\frac{1}{2}$ to $1\frac{2}{3}$; ventral $2\frac{1}{10}$ to $2\frac{1}{5}$. Anal papilla moderate.

Color in alcohol with back largely burnt umber, with 3 dark to blackish saddles, broadening as blotches above median lateral axis. First saddle includes most of spinous dorsal, second from hind half of soft dorsal base and third not crossing caudal peduncle, but invading caudal base. Dusky loup across occiput. Under surface of head and belly pale, with dusky or smutty-brown spots. Dusky blotch before, below and behind eye. Soft dorsal and caudal gray-brown, with 6 or more blackish cross-lines. Pectoral pale brownish, with 6 transverse lines of deep brown. Two dusky-black spots at pectoral base, both externally and in axil. Ventral whitish, with median dusky blotches.

Length 72 to 165 mm.

Twelve from Ningkwo.

TETRODONTIDÆ***Spheroides rubripes* (Schlegel)**

Head contained $3\frac{1}{8}$ times in length to caudal base; depth $2\frac{3}{4}$. Dorsal iv, 12 to 15; anal iv, 8 to 10; pectoral i, 17 or 18. Snout $2\frac{1}{4}$ to $2\frac{1}{2}$ in head; eye 6 to 7; mouth width $3\frac{3}{5}$ to 4; interorbital $1\frac{5}{6}$ to $2\frac{1}{6}$.

Body robust, moderately long, deepest about pectoral base and back broadly convex. Caudal peduncle conic, least depth $1\frac{4}{5}$ its length or $3\frac{3}{4}$ in head.

Head about as wide as deep, upper profile evenly convex; width $1\frac{1}{8}$ to $1\frac{1}{5}$ in its length. Snout broad, convex over surface and in profile, length $\frac{2}{3}$ to $\frac{3}{4}$ its width at front of eyes. Eye small, elevated, hind edge midway in head; diameter $2\frac{1}{3}$ in snout, $3\frac{2}{5}$ to $4\frac{1}{8}$ in interorbital. Mouth moderately wide, terminally inferior. Lips thick, fleshy, with striate papillæ, which also extend over most of lower jaw or mandible. Teeth with entire edges, median groove well defined above and below. Nostrils lateral in oval cutaneous sac, outer slit much the larger; falls just before last fourth in snout profile. Interorbital widely convex.

Gill-opening 4 to $4\frac{1}{4}$ in head. Line of lateral mucous system encircles eyes, then follows along upper side of back well above pectoral back to middle of caudal base; branch below nasal sac, another above pectoral origin upward and finally one from junction behind eye downward. Predorsal, interorbital, postorbital, breast and abdomen with prickles, slightly larger on abdomen, variably more or less meeting behind depressed pectoral.

Dorsal begins a little nearer caudal base than pectoral origin, rounded or median rays longest; fourth ray $2\frac{1}{8}$ to $2\frac{1}{5}$ in head. Anal similar and opposite dorsal; fourth ray 2 to $2\frac{1}{10}$ in head. Caudal convex behind, $1\frac{1}{3}$ to $1\frac{3}{4}$ in head. Pectoral broad, hind edge convex, reaches $\frac{2}{5}$ to $\frac{1}{2}$ to anal, 2 to $2\frac{1}{6}$ in head.

Color in alcohol dark neutral-gray on back, below whitish. Blackish blotch opposite hind half of depressed pectoral and another at dorsal base both with line of pale to whitish boundary. Four or 5 similar pale lines cross back, often broken or variably incomplete. Fins pale, often dark spot at pectoral base. Iris pale slaty.

Length 116 to 143 mm.

Eleven from Ningkwo.

A very interesting species, quite strikingly marked and not rare in China and Japan. Not previously reported from Chinese fresh-waters.

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